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The B.R.M.

IN the *Automobile Engineer* for February, 1948, under the heading of "Racing or Research ?", the views of this journal were stated regarding an ambitious project involving the construction of a team of Grand Prix racing cars. Nothing has occurred since then to warrant any fundamental modification of the opinions expressed. Briefly, these were that technically Grand Prix racing is a sterile field so far as the main trend of automobile engineering is concerned. Further, from the purely technical aspect, the benefits arising from success in this particular form of competition are at best debatable. The very considerable finance involved would be far better spent in co-operative research.

While success in Grand Prix racing, or other such achievement may result in publicity and prestige to an industry and even to a country as a whole, the penalty for failure, particularly ignominous failure, is a substantial discredit. Public opinion, lacking detailed information, or for that matter careless of the finer points involved in these affairs, does not waste time on inquests. It looks only for the first three place winners in the race results, and indeed, why should it look further ? The atmosphere of Grand Prix racing has nothing in common with the caucus race in *Alice in Wonderland*, wherein the Dodo concluded that "Everybody has won and all must have prizes".

Unofficial Status

Much confusion has arisen in the public mind regarding the status of the B.R.M. in relation to the motor industry in general and the Government. Although entirely without foundation, the impression appears widespread that the B.R.M. is not only a co-operative effort on the part of the industry, but also that it has some National support. This view is doubtless held in other car-minded countries, and on this account the dreary history of delays, culminating in the utter failure of the B.R.M. to turn a wheel at its first appearance in competition, cannot be regarded as anything but a blow to British engineering prestige.

It is indeed difficult to see how at this stage the motor industry can refrain from taking some action with a view to both checking the present debacle and restoring as much of our technical reputation as may be now saved. At the risk of labouring this point, it must be repeated that while the value of success in this form of competition is debatable, the consequences of purely technical failure cannot well be over stressed, particularly as it is so widely believed that the venture is something in the nature of an Official project.

Lest it be thought that failure is too harsh a word to use at this stage in the car's development, the fact is that on the basis of elapsed time, the car should by now be in the final stages of development and entirely race-worthy. There is nothing about its performance, so far, to suggest that in present hands, the ultimate success of the car can with any confidence be anticipated. It is now about five years since work began, and eighteen months since an engine first ran on the test bed. In December 1949 the car was demonstrated, and again in May this year. Yet without special concession it was unable to complete the required qualifying laps at Silverstone in August. This does not seem to indicate that development has been pressed forward with reasonable insight and competence.

No Withdrawal

The drift from one crisis to another has resulted in a situation from which a graceful withdrawal is impossible. Indeed, such a course would merely invite the derision not only of the public at home, but also the public in countries that may by now have fading memories of British technical superiority in different but related spheres a few years ago. It is therefore evidently too late to allow the B.R.M. to pass into the limbo of projects best forgotten. A great effort must be made to retrieve past mistakes and wasted time, and to put the whole project on a sound basis at once so that by the beginning of the 1951 season the car can take the field, if not with complete success, at least in a manner that will not lead to complete disgrace.

Let us hope that firm action will be forthcoming, such as will after all, fulfil the hopes expressed by the Chairman of the British Motor Racing Research Trust last December, but which have been so poorly manifested in practice by

his Committee. Given financial support and sufficient determination, it can be done. The basic layout of the car is full of promise, and full credit must be given to those who have supplied components and to those who have co-ordinated the design at drawing office level. What appears clearly lacking is competent technical leadership. It may however be not unreasonable to question whether the Trust as constituted, should be the sole arbiter in this matter, in view of results up to the present.

Automobile engineers might feel more confident of ultimate success if the project were forthwith to become a matter of *direct* concern to the industry, preferably established within the factory of one of those who have already lent material support. Whatever the industry may feel about Grand Prix racing, it can hardly stand aside when a project that has willy nilly been associated with it in the public mind, has so far only resulted in a lowering of its prestige. It is unfortunate that ill-conceived publicity should have brought the shortcomings of the car into such world wide prominence and so brought about such an unhappy reflection on our technical reputation and upon British industry. That, however, is the present position. The car can be made ready in time for next season's racing, given material support, and really competent technical direction. Unless this is forthcoming there may be real cause for regret that an unpleasant and damaging situation was not tackled decisively and firmly before further harm resulted.

Progress in Research

AN encouraging account of the state of scientific and industrial research in this country is given in the D.S.I.R. report for the year 1948-49. Particularly worthy of study is the report of the Advisory Council, which includes some pertinent observations on the many difficult problems that must be faced. As the Council truly say, "In these critical times it is essential that the tasks for which the available resources are used should be, not merely useful, but the most useful that can be undertaken for restoring the prosperity of the country. It is no less essential to ensure that every practicable step is taken, once a piece of work is finished, to apply the results in practice". The various Research Associations sponsored by particular industries must play an increasingly important part in industrial developments.

That in industry in general there is increasing realization of the value of co-operative research is shown by the rapid increase in the number of Research Associations since the war. Forty such Associations have been established in particular industries with government help. Eleven have been in existence twenty-five years or more, while sixteen are less than five years old. In almost every case they are working under great difficulties. Some, such as financial stringency, could be eased by more generous support from industrial organisations. Others such as lack of adequate buildings and shortage of highly trained technologists, must be borne for some years yet.

Despite the admitted difficulties, the Council suggest an extension of Research Association activities into work outside laboratory research on materials and processes. Briefly, the suggestion is, "that Research Associations may, either directly or indirectly through related bodies, provide for their industries a scientific service bearing on all aspects of production that their Councils may determine, including, it may be, works organization". It is to be hoped that eventually the Associations will find it possible to implement this suggestion. What is envisaged is that the physical science and engineering work shall be linked with sociological and economic studies.

The record of this country in fundamental research is unsurpassed, but it is doubtful whether the quickest and fullest use is made of the results. Here again, the Associations play an important part. They are in day-to-day touch with industrial organisations and most of them now maintain liaison officers to help industry translate the results of research into action. In the final analysis, however, the use made of the work of these Associations depends solely upon the initiative shown by individual organisations. In connection with this problem, the Council consider that where failure occurs in the collaboration between industries and the Associations, it is because there are not sufficient technically trained people in positions of control and authority. This may in part be due to a shortage of highly trained technicians, but often it may arise from the fact that overriding control is exercised by financial and commercial staff.

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COMMERCIAL VEHICLE SHOW

A Survey of the Bodywork, Electrical Equipment and Front Axles

BODYWORK

Changes Brought About by Underfloor Engines

ONCE again coachbuilders have demonstrated their ability to produce bodywork to suit all purposes. Passenger-carrying vehicles catering for both home and overseas requirements show steady improvement both in design and construction, whilst trucks and vans to suit every conceivable load, evidence the fact that the builders have studied with care the demands of widely differing transport operators. Apart from the two classes of commercial vehicles already mentioned, a type which is very close to the private car industry is the ambulance, and in this field some excellent examples are now being produced.

It is interesting to note that amongst the exhibitors at this year's exhibition were coachbuilders who for many years have restricted their activities to the private car industry. Without doubt, the uncertainties and restricted outputs have prompted private coachworks to apply their energies to a type of bodywork for which there is a steady demand.

One of the highlights of the Exhibition was the predominance of underfloor engined passenger vehicles. This layout, which from a body design viewpoint is long overdue, combined with changes in legislation on dimensions, has done much to bring this country's products into line with those produced abroad. We are now in a much better position to compete with overseas producers in their own market.

At the preceding Exhibition it was noticeable that much closer attention was being paid to external appearance, and it was evident that private car trends were to some degree being followed. This is still apparent, but it is obvious that more severe lines which in the past have characterised certain overseas productions are now being used, again no doubt, with the object of appealing to overseas buyers. The introduction of the under-floor engine has also had its effect upon appearance, and full-width cabs making use of the floor area adjacent to the driver are not uncommon.

A body making full use of the legal dimensions, and also mounted on a chassis having an under-floor engine was that shown by Duple Motor Bodies Limited on a Leyland Royal Tiger chassis. This body is known as the Roadmaster Luxury Coach and provides accommodation for forty-one passengers. In its construction, the all-metal framing utilising alloy pillars derives considerable strength from the interior steel lining, which is suitably stressed, whilst the exterior panels are of aluminium. The main entrance to the body is at the front, forward of the front wheels, a feature made possible by the modern engine location, whilst the emergency door is on the offside opposite to the entrance. Full drop windows are provided, and all exterior mouldings are of polished untarnishable alloy, and include special concave mouldings of considerable depth at the waist and mid-panel, giving some protection to the body sides.

At the rear of the body there is a large capacity baggage compartment, and further accommodation is afforded by wide and deep interior parcel carriers. Double sliding panels are used in the roof, and the front canopy houses the ventilation equipment. This body, which is intended for service in this country, is 30ft. long, 8ft. wide, and has an unladen height of 10ft. 1½ins. overall. The builders point out that this particular design of body is available for various makes of chassis having an under-floor engine, and can be produced to a width of 7ft. 6in. For export markets its length can be increased to 32ft. 9in.

Another outstanding vehicle was that shown by Windovers Ltd. on an A.E.C. Regal Mark IV chassis which also has an under-floor engine. This 30ft. by 8ft. coach seats only thirty-one passengers, but this is explained by the very full equipment which includes a sandwich and cocktail bar behind the driver, and also a courier's seat, whilst between the seats above the wheel-arches is a table that incorporates a heater. This vehicle which is of distinctive appearance having a series of horizontal mouldings on the lower panels, is intended for Continental operation. The full-width four-piece windscreen with curved side panels, combined with the curved and somewhat aggressive front panels, should attract much attention.

An interesting feature of a thirty-two passenger coach shown by Mann Egerton & Co. Ltd., on a Maudslay Marathon chassis, is the provision of a full-length double wardrobe to accommodate raincoats and overcoats. This is arranged at the rear of the body and has hinged doors giving access to the inside of the rear boot locker. This coach is particularly well equipped, and is fitted with the new Radiomobile Personal installation which enables

Leyland "Royal Tiger" bus.

Park Royal export body on a Maudslay.

each coach passenger to receive a radio programme through a loudspeaker embodied in the head-rest, there being also a volume control and switch. This Mann Egerton body is one of several fitted with this radio installation.

A particularly interesting exhibit was the coach shown by John C. B. Beadle (Coachbuilders) Ltd. who are pioneers of the integral system of body and chassis construction. In the example exhibited, seating accommodation is available for thirty-five passengers, and full use has been made of the floor space available, for this coachbuilder has not taken advantage of the increased allowance of length now permitted. Similarly, the construction of the side framework is such that greater width is possible between the pillars even though the overall width has been kept to 7ft. 6ins.

The driver is not enclosed in a separate cabin, and thus, the interior appears to be more spacious than is usual, whilst at the same time, the omission of a bulkhead provides better vision for the passengers. An interesting feature is the use of glazed roof ventilators, which apart from their primary purpose, add still further to the general impression of roominess.

Luggage is carried in a rear panel boot, and ample rack accommodation is provided inside the vehicle. The heater introduces fresh air which can thus be warm in winter and cool in the summer. This Beadle chassisless coach embodies a Sentinel-Ricardo engine, and the other mechanical units are of Sentinel manufacture.

An elaborate 30-seater coach of maximum legal dimensions, and mounted on A.E.C. Mark IV chassis was shown by H. V. Burlingham Ltd., this coach being specially designed for extended and Continental tours. The entrance with flush type sliding door is amidships, with the emergency exit opposite. In the rear offside corner of this body is a toilet compartment completely equipped and glazed in obscured glass. Adjoining the toilet compartment is a cocktail cabinet with sink and icebox. In addition to the Quicktho type sliding windows of the hinged ventilator type which are fitted on each side of the body, further fresh air can be obtained from the two single panel sliding roofs, and the roof border panels are carried out in curved safety glass. Approximately 200 cubic feet of space is available for luggage in the rear locker and along the parcel racks, which are of the tubular pattern to reduce roof window obstruction to a minimum. The individual reclining seats with arm and foot rests are trimmed in moquette and leather on a foam-latex foundation. The same coachbuilder showed a 37-seater luxury coach on the Maudslay stand, and this body is of composite construction with interior arrangements giving a sunken central gangway with ramped seat platforms at each side.

An observation coach with accommodation for 35 passengers was shown by James Whitson & Co. Ltd., this body being mounted on a Foden chassis. The lower saloon seats eighteen passengers and the upper saloon seventeen. This arrangement makes possible a spacious luggage compartment at the rear, this compartment also carrying the spare wheel in an upright position. The roofs of the upper and lower saloons have Perspex transparent panels giving a high degree of visibility.

The vexing question of dust infiltration into the body has received particular attention in the design and construction of the 40-seater Pullman coach shown by Thos. Harrington Ltd. on a Leyland Royal Tiger chassis. The heating and ventilating system which draws fresh air from an intake at waist level incorporates ducting to the rear luggage locker, and in effect, pressurises this compartment, thus causing a permanent outflow of air at any crevice which would otherwise readily admit both dust and fumes. In this body, which is built to maximum legal dimensions, the main entrance is in the centre of the nearside panel and is fitted with vacuum press button control. The fixed roof embodies four perspex centre panels all of which are provided with sun-blinds.

Maximum luggage space is provided by a double floor which also eliminates wheel arches, the total luggage capacity being 136 cubic feet. Cantilever type interior roof racks incorporate continuous lighting and ventilating grills.

Dennis "Horseshoe" coach with Gurney Nutting body.

The Clayton heating and ventilating unit is fitted under the floor and feeds warm air into the body by ducts built into the body side at floor level. This Harrington body, in common with the other two coaches exhibited, is fitted with the patented dorsal fin in the rear roof dome, this feature forming part of the ventilating system.

A full range of public service vehicles was shown by the several companies comprising the Metropolitan-Cammell-Weymann group. On Weymann's stand there was an interesting single decker of the type known as the Olympic which is of integral construction utilising Leyland mechanical components. The structural members carrying the power and running units are of steel, whilst the pillars, longitudinal members, roof framing and outer panels are of aluminium alloy. A substantial aluminium alloy bumper is carried all round the vehicle, and from the bumper to the waist line the outer panels are of heavy gauge and form part of the load carrying structure. Below the bumper the outer skirting is either in the form of detachable valances or readily replaceable light gauge panels. Snap-headed rivets are used for securing the outer panels to the framing, and to resist corrosion the wheel arches are of stainless steel.

Red and White coach body by Duple.

Whitson 35-seater observation coach.

Special attention has been devoted to the question of fume exclusion, and noise insulation is also a feature. Seating is provided for 44 passengers, and the tubular steel seat frames have Dunlopillo fillings with trimming in moquette and leather. For the operation of the front door C.A.V. electrical equipment is used and there are ten half-drop windows of the Beclawat "Zephyr" type.

Particular interest from the operator's view point attaches to the rear entrance and front exit single deck trolley bus which is shown by Weymann on a B.U.T. two axle chassis. This trolley bus is in the nature of an experiment which the Glasgow Corporation are proposing to make. Although the vehicle has overall dimensions of 30 feet by 8 feet, it has only seating accommodation for 28 passengers and is designed to give the maximum standing capacity, and should thus provide a fare-paying load of over sixty people.

The body is of M.C.W. patented metal construction incorporating pillars of steel tubular section, steel sheets being riveted in position between seat rail and waist angle for the whole of the body length, the front and rear ends being similarly constructed. For the attachment of exterior panels and mouldings, hardwood is inserted in the main pillars and horizontals, whilst the under frame comprises 3in. joist section steel connected to the pillars by steel brackets riveted into position. For the roof framing, channel section is employed, and steel carlines connected by longitudinal steel pressings are secured to the cant rails and pillars by steel brackets. This provides a roof of considerable strength and gives a smooth appearance, the interior and exterior roof panels being in sheet aluminium. There is a roof gangway with timber treads for access to the trolley gear. Concerning the exterior panels which are in sheet aluminium, an interesting point is that the rear

Coach by Associated Coachbuilders Ltd. on a Jensen chassis.

Guy chassis with double-deck coachwork by Strachans.

corner panels are composed of rubber. Both the rear entrance and the front exit are fitted with double folding hinged doors equipped with electrically operated gear.

The seating arrangement for the 28 passengers consists of accommodation on double and single seats giving a wide central gangway, and the double seats are designed to provide a staggered arrangement. A conductor's tip-up seat is provided within the saloon and is on the near side against the rear bulkhead. A hinged counter is arranged immediately in front of the conductor's seat to facilitate the collection of fares. The driver is fully enclosed and his cabin has a sliding door on the near side partition.

An interesting vehicle on the Metropolitan-Cammell stand was a single-deck 40-seater service bus for use by the Montevideo Municipality and is an export version of the Leyland-M.C.W. Olympic bus. The vehicle is of integral design, with structural members of steel carrying the power and running units, aluminium alloy being used for the side and roof framing.

Metropolitan-Cammell also exhibited two double-deck buses, each of which is constructed on the M.C.W. patented metal system, embodying tubular steel pillars with inner steel truss panels riveted in position. In this case also, the outer panels are of aluminium screwed to hardwood furrings and are thus easily replaced in the event of damage. In the case of the 54-seater version intended for service in Birmingham, the rear entrance platform leads to a wide straight staircase, whilst the 58-seater passenger version which is for service in Manchester, is 6ins. wider and has a rear entrance platform giving access to a wide right angle staircase.

An unusual type of passenger carrying vehicle was shown by British Trailer Co. Ltd., who exhibited an articulated vehicle in which the prime mover was an Austin Loadstar. The body has accommodation for fifty passengers and to facilitate shipping, the body is built in sections.

On the Leyland stand one of the new Royal Tiger chassis with under-floor engine was shown with coachwork by Saunders, and is one of a large order recently placed by an Havana undertaking. Since no stripped chassis was shown the manufacturers took the opportunity of arranging glass panels in the floor so that the general details of the major under-floor units could be inspected. In many respects, the body is similar in layout to the U.S.A. Transit type coach, with an air operated jack-knife entrance door forward of the rear wheel and a similar exit door in front of the front axle. The body framework is formed of alloy pillars with continuous steel seat and floor members and intercostal waist rails. To these the steel external panels are chobert riveted, whilst the steel lining panels are solid riveted, since these panels are required to take all working stresses. A double skinned insulated roof is fitted.

Connection between body pillars and chassis outriggers is made by means of rolled steel angles which are bolted to both components. Basically the floor structure is formed by the chassis, half-lapped $\frac{3}{4}$in. thick boarding being laid longitudinally and is fixed by wood screws to timber packings that are bolted to the chassis cross members.

Among the many interesting truck and van bodies to be seen was a mobile workshop shown by Leyland, and based on a Comet semi-forward controlled chassis. This well equipped unit, in addition to two workshop rooms, has a sleeping compartment. Thus there are three compartments, a workshop and stores, dust-proof test room and a sleeping compartment, extensive under-floor locker space being provided for heavy gear such as jacks and lifting appliances.

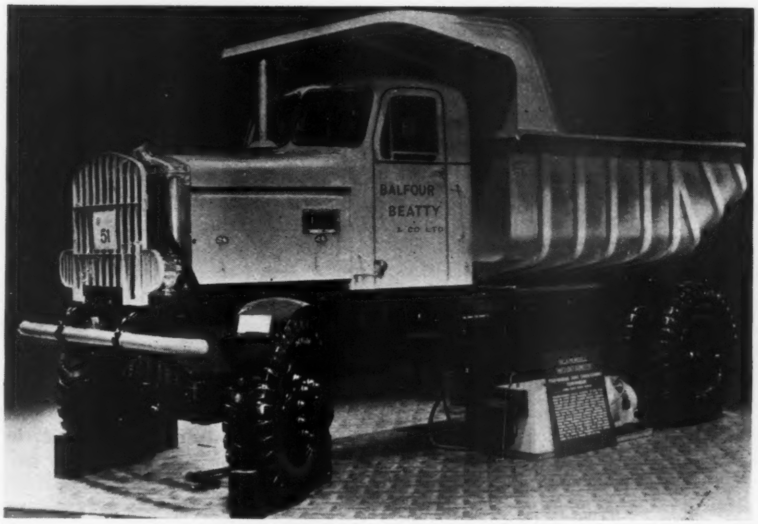
The workshop and stores compartment is at the rear of the van, and the rear panel of the vehicle is hinged horizontally so that a lower flap can be dropped to form an extension to the floor, thus increasing the area of the workshop. To protect this floor extension, an upper panel can be raised. In addition to the usual work bench, tool lockers, storage bins and writing desk with its racks for log books, an extensive range of hand tools and special purpose appliances, including gas welding plant, are housed in this compartment. The dust-proof test room is situated on the offside of the van, forward of the workshop, from which it is separated by a hinged door,

Van body by Hooper & Co. (Coachbuilders) Ltd.

and air for ventilation is drawn in through cleaners and is extracted by two fans. The sleeping compartment is on the near side of the van, being forward of the workshop, from which it is separated by a sliding door. This compartment is equipped with a bed and has a locker below it for personal kit. A stainless steel washbasin draws water from an under-floor storage tank by means of an electric pump.

Hooper & Co. (Coachbuilders) Ltd. have a long tradition in the building of distinctive private cars and are interesting newcomers to the ranks of commercial vehicle builders. In the three vehicles they exhibited it is obvious that a lifetime of high class body-building has been used to good advantage. Of particular interest is the special "direct sales" van on a Morris Commercial "J" type chassis. This body has a serving hatch on the near side and the rear doors are made to open to enable the driver to serve his customers from the inside of the vehicle. The lower half of the door is fitted with a counter and behind the driver are insulated containers for ice cream, and there is, of course, the usual washing kit for the use of the driver. Other exhibits by this coachbuilder include a Luton type delivery van on a 2-ton Karrier Bantam, and a van body on a 10-cwt. Fordson chassis.

The use of light alloy in the construction of truck bodywork is steadily gaining ground. Bonallack & Sons, Ltd., in their exhibit of a 24ft. long flat platform body on an A.E.C. chassis illustrate how a body weighing under 10-cwts. can withstand the heavy usage to which it will be subjected when used for the carriage of bricks. The basis of this body is the Dekaloy floor which is laid on lipped channel bearers with Sherardized bolts. The main side members are of hollow box sections and the front bulkhead is panelled in 14 s.w.g. alloy plate. This bulkhead with its heavy angle section top rail and two intermediate "top hat" standards is robustly stayed to the body with deep 10 s.w.g. alloy corner brackets.



Scammell "Mountaineer" cross-country tipper.

Another special purpose vehicle of attractive design was a mobile canteen shown on an Austin 25-cwt. chassis by J. H. Jennings & Son, Ltd. On the near side this body is fitted with a hinge-up canopy and a hinge-down counter for serving purposes. The dome roof has plastic corner lights and there are also extractor type ventilators. The interior appointments are comprehensive and include tea urns, stainless steel sink with draining board, ice cream conservators and fruit cordial dispensers whilst Calor gas equipment is also installed.

This concern also exhibited a well designed horse-box mounted on a Bedford passenger chassis, and a feature of this vehicle is the substantial kicking pad to the lower surfaces of each stall. There are strong plywood stalls cut to shape and battened for extra rigidity and the upper surfaces are padded and covered with leather. There is a groom's seat in each rear corner, and the interior lights and communicating buzzer are controlled from a panel at the rear. Each stall is double floored, a necessary item in such bodywork, and the body is mounted on hardwood cross bearers, plated where necessary.

There were several good examples of ambulance bodywork, and on a Bedford ambulance chassis, Spurling Motor Bodies Ltd. exhibited an all metal ambulance body giving accommodation for one recumbent and five sitting cases. In this body the floor and under framing is composed of mild steel sheet, whilst for the side framework mild steel sections are used. There are full width doors at the rear the driver's cab being divided from the body by a half depth partition, and has seating accommodation for the driver and two passengers. In the rear compartment there are on the near side three single coach type seats set aslant, and on the off side the stretcher gear is upholstered to carry four persons or can be adjusted to carry one stretcher case. In addition the attendant has a tip-up seat.


Martin Walter "Utilabus" ambulance.

ELECTRICAL EQUIPMENT

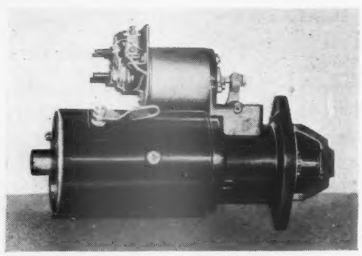
Improvements in Mechanical Design

IT has been increasingly evident in recent years that progress in design of the basic units employed both for starting and lighting installations was limited by the electrical or magnetic characteristics of the materials commercially available to the manufacturer. Further, it might even be said that if commercial considerations were ruled out, the improvement would hardly be of more than technical interest. Mechanical design is less restricted by such considerations and there is no doubt that a very high standard has been attained both as regards reliability and also ease of servicing. This matter is intimately bound up with standardization and it would seem that it is only in this direction that progress can be expected.

Starting Motors

In starting motors for the larger engines, particularly where space is limited, the same standard machines continue to be used and to give satisfaction. The C.A.V. axial type and the Simms S type are used and the same methods of mounting are employed. These two machines have been fully described previously and the latest designs evidence only slight and unimportant detail changes. For instance in the Simms S type motor, grease lubrication is now used for the driving end bearings but no change has been made in the switch control. Two greasers are fitted, one on each side of the machine, so that one is always accessible. They are practically inverted grease cups and do not project beyond the frame of the machine.

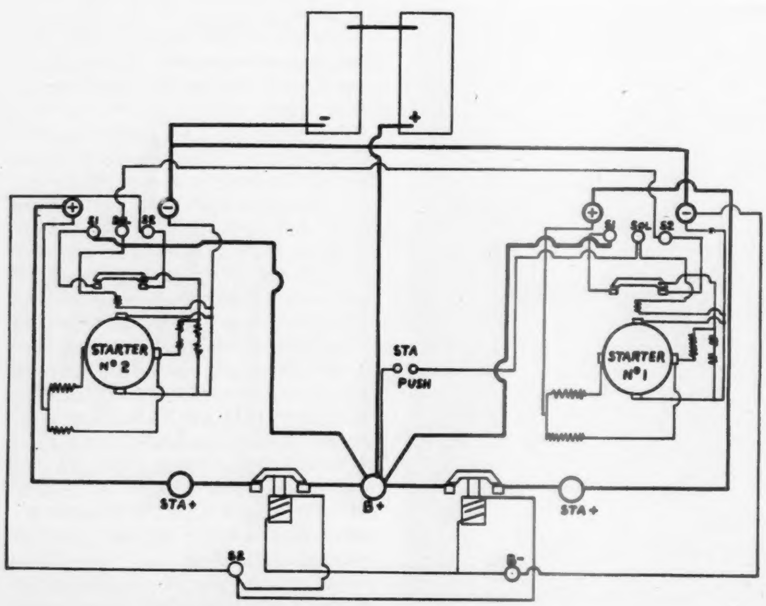
In both the C.A.V. and the Simms motors, the pinion is brought into engagement with the teeth of the flywheel and all back lash taken up before the full starting torque is applied. This fact makes it possible to use two starting motors if desired for a very large engine, as in the case of the Thornycroft "Antar" and the Meadows 15.9 litre engine. For this purpose the connections are so arranged that the two starters are in series for the first stage, which is engagement of the pinions, and in parallel when this is complete and full torque applied.



Lucas solenoid operated starter.

In the C.A.V. system when the starting button is depressed, a small current flows through the auxiliary coils of No. 1 starter, causing the armature to rotate slowly. The magnetic field set up, pulls the armature forward gently into mesh with the flywheel teeth. The last part of the motion operates the switch trigger that releases the contacts of the solenoid switch. This is the normal operation of the starter, but in this application, the closing of the solenoid switch allows current to pass to No. 2 starter, but does not apply full current to the armature. No. 2 starter functions in the same way as No. 1 except that release of its own trigger switch passes current to the dual starter switch No. BBNFA-15 unit. The switch then closes and allows the full current from the battery to flow through both starters so that they exert their full torque on the engine simultaneously. The wiring diagram shows the connections between the units. It is interesting to note that Nife batteries have been chosen for this installation.

The Lucas starter as used on the Commer Q.X. vehicle is of interest. The pinion is pushed into engagement by a solenoid mounted above the machine and connected to the pinion by linkage. Full voltage is applied to the starter terminals when the pinion is fully engaged. The larger units when fitted to C.I. or petrol engines operate on the two-stage principle and it is only on the smaller petrol engines that the simple inertia form of engagement is permissible.



Connections for C.A.V. dual starter switch.

Batteries

All the large machines operate on 24 volts and even then the large current taken and the duration of the start (in C.I. engines) imposes a heavy strain on the batteries. For example, 300 amperes at an initial pressure of 24 volts is not an unusual figure and voltage drop becomes serious unless a large and heavy battery is used. This current at 24 volts is equivalent to about ten horse-power which brings some realisation of how much is expected of the battery. The voltage, however, does not remain at 24 and an initial drop of 20 per cent. to 30 per cent. or more can occur in normal working with a battery of 80 to 120 ampere hours capacity. The effect is to a large extent cumulative, as it lengthens the duration of the starting by reducing the power of the starter and in consequence the strain on the battery is increased. Every effort continues to be made by the battery

makers to cope with this by obtaining greater porosity of the plate material, improved acid diffusion and, of course, the lowest possible internal resistance.

These aims are unfortunately conflicting, and involve complicated designs in armouring or sheathing of the positive plates, elaborate separaters and intricate grid shapes. The methods employed vary in different makes, but in general wood separaters continue to be used and are assembled with their flat backs to the negative plates. Further protection is given to the positive plates by some form of glass wool. In the Young battery the positive plate is in a complete envelope of glass fibre sheet bonded with resin and made to enclose the sides and bottom of the plate. In the Chloride design the glass wool is finely felted and is in the form of sheets overlapping the plate at both sides. Peto and Radford in their "Shednought" batteries enclose the negative plate in micro-porous plastic envelopes. The design of the grid, particularly that of the positive plate, plays an important part and the requirements are again conflicting. The new Lucas positive plate and grid are of interest. In this construction the paste is carried in fairly thin vertical strips which are each completely enclosed in very thin perforated ebonite sheaths. Wood separaters are used and the negative plates are of the standard flat type and bear against the flat side of the separater. Both plates rest on a porcelain frame in which space is provided for sediment.

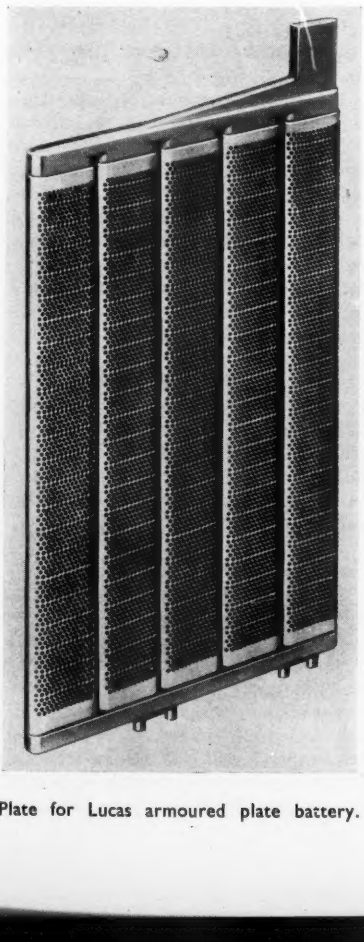
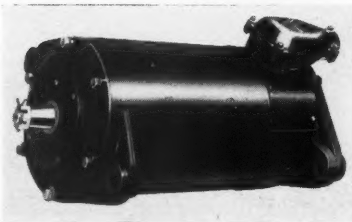


Plate for Lucas armoured plate battery.



Simms 7D enclosed dynamo.

A full range of Nickel Cadmium Alkaline batteries is shown by Nife Batteries of Redditch and by C.A.V. The Nife Co. exhibited a typical example of a traction battery and a battery of the type supplied to London Transport for all their trolley buses. The traction battery consists of 24 cells with a capacity of 300 ampere hours and the trolley bus manœuvring battery of 48 cells with a capacity of 60 ampere hours. These steel alkaline batteries are particularly suited to duties of this type owing to their ability to withstand any amount of hard work or even ill-treatment without impaired efficiency or life.

Dynamos

A complete range of dynamos was shown by the Simms Company and also by C.A.V. The Simms exhibit comprised a 4½in. Dynamo No. 4512 DA series which had not been shown previously. It is a 12-volt machine totally enclosed. Other models of 5in., 5½in., 6in. and 7in. were also shown and have been referred to previously. These are all 24-volt ventilated machines and are supplied for cradle or swing mounting as required. The general design remains as before though detail changes have been made. For instance, the 7in. model now has a new terminal box which can be reversed if required to facilitate wiring.

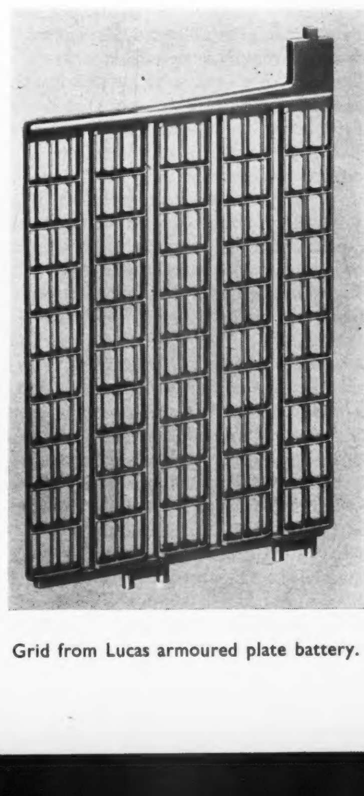
A selection of the latest C.A.V. dynamos were shown in sizes from 5in. to 7in. yoke diameters. All machines are ventilated and practically unchanged in general design. They are normally wound for 24 volts but other voltages are available if required, and either cradle or swing mountings can be supplied.

Belt drive using twin and triple rubber belts is used in the majority of installations and there are many examples in which the dynamo is mounted at one side of the gearbox, the belt drive being from a pulley on the front end of the mainshaft. The larger machines are generally cradle mounted either on the crankcase or behind the engine and positively driven from the engine. All dynamos are now highly rated and as they depend on their ventilation for satisfactory operation, there are fewer instances in which the cradle is integral with the crankcase.

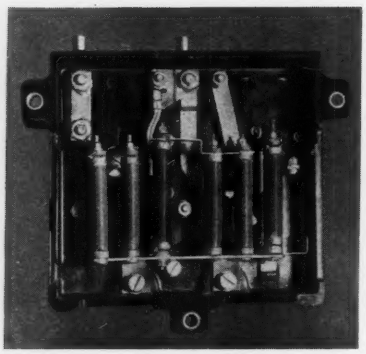
Voltage control is, of course, universal on all models and the fields are designed to operate with single regulators in nearly all cases. Combined voltage and current control is adopted on some of the new control boards and they are simpler and more compact than before.

A good example is the C.A.V. 2V2 type control board with current voltage control and relay type cut-out. All parts of the regulator unit except the cores are made from flat strip and are mostly interchangeable. Adjustments are all on top and accessible. The voltage coils are standardised in 12 and 24 volt types and on the current side the coils are standardised to suit the various dynamo outputs.

In operation, when the battery is in a discharged condition, the current regulator takes control and continues to allow the dynamo to give its maximum output until the battery has acquired about 70-80 per cent. of its full charge so that it is brought as quickly as possible out of the danger zone where sulphating exists. Its voltage has by that time risen to the setting value of the voltage regulator which then takes over from the current regulator and reduces the current by



Grid from Lucas armoured plate battery.



C.A.V. control board type 201 from below.

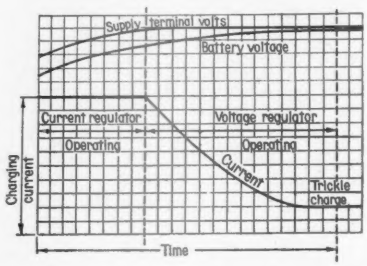
degrees until the battery is fully charged, when the current is reduced to a trickle charge.

The cut-out consists of a relay and a solenoid switch built into one unit. In operation the relay is controlled in the same manner as the normal cut-out and carries a shunt and series winding, but its contacts control the solenoid switch which makes or breaks the main current. This gives a very quick make or break and so reduces contact burning of the main contacts. The relay contacts are lightly loaded as they only carry the solenoid shunt winding current and have a long life in consequence.

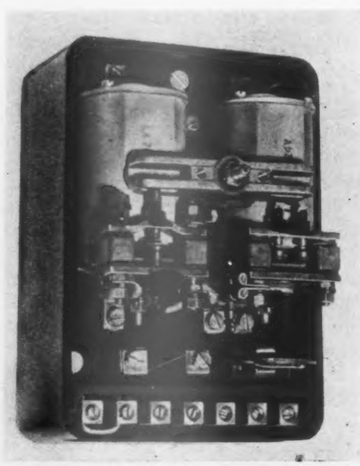
The Simms ED series control board is shown for the first time and operates in the compensated voltage control system. It embodies a single stage voltage regulator, the shunt winding of which is of comparatively low resistance. To avoid change in regulator settings due to variations in temperature, this winding is connected in series with an external resistance having a negligible temperature coefficient. This acts as a swamping resistance, and changes in the resistance of the actual windings due to temperature make little difference to the voltage settings.

The actual cut-out is replaced by a pilot relay and contactor, and is standard practice for use with machines having an output in excess of 30 amps. The pilot relay is a normal reverse current relay with one amp. contacts. Its shunt coil is connected between the dynamo terminals of the control board, and the one amp. contacts are connected in series with the operating coil of the contactor. These in turn are connected, via the pilot relay contacts, between the dynamo terminals. The contactor is designed to pull in at 90 per cent. of the system nominal voltage, consequently when the pilot relay closes, the contactor immediately follows and instantaneously closes the main circuit. Also in the main circuit, in series with the contactor contacts, is the pilot relay series coil. When the E.M.F. of the generator falls below that of the battery, a reversal current flows through the pilot relay series coil, causing the contacts to open. The contactor follows immediately, breaking the main circuit definitely and rapidly. In this system the pilot contacts are lightly loaded and in consequence very durable, and the main contacts are given a rapid opening or closing, so reducing burning due to the heavy current they carry.

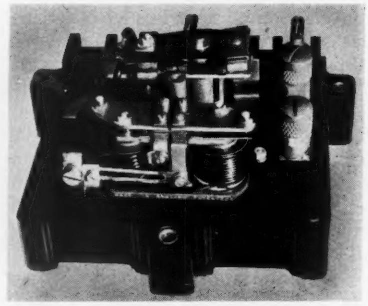
The C.A.V. control board type 186-4 as shown on the Albion Clydesdale chassis is another example of compact design and consists of a bakelite moulding forming the box for the units. It is really a combined switch and control board, housing a combined regulator and cut-out, main lighting and auxiliary fuses, starter and lighting switches and also ammeter. Both the ED series control board and also the EG series employ voltage control only, as distinct from current voltage control. The ED series is used for large dynamo outputs and a space is left in both of these boards for a current regulator, which can be fitted if specified and becomes standard equipment. The EG series board is for smaller dynamo outputs and employs two stage regulators, as will be seen from the illustrations.



Diagrammatic output curve with current voltage regulation.



Simms EG type control board.



C.A.V. control board current voltage regulator.

The accompanying hypothetical curve shows how the current delivered by the dynamo to a battery in a discharged condition is maintained at a high value when a system of combined current voltage control is in use. It will be seen that the current section of the regulator unit maintains the output at the maximum value the generator can safely deliver until the voltage of the battery has reached the value at which the voltage regulator has been set. Should a heavy lamp load be imposed on the system in addition during the interval, the total current output from the dynamo will still be kept at the same maximum figure, but the battery will receive the balance of current available after the other load requirements have been fulfilled.

When the compensated regulator comes into operation the current section ceases to control and the output falls progressively until only a trickle charge is given to the battery. This, of course, will be in addition to the lighting or other load carried by the system. With the compensated voltage control only in operation the initial peak current may exceed the value given by the combined unit, but it will rapidly fall away to a value considerably below the figure at which it would be maintained by the combined unit. The system shows to full advantage when heavy loads have to be dealt with and in the case of small installations the compensated voltage control system appears adequate.

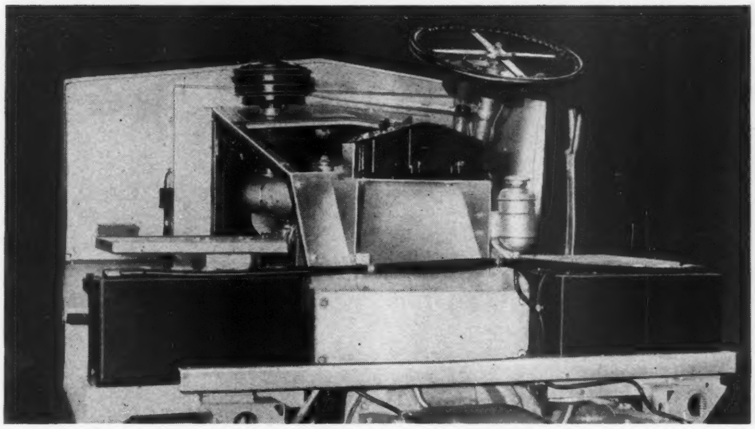
Lamps

Heavy vehicle road lamps are approaching still more nearly to the usual private car pattern and are generally in the form of flush fitting units mounted on the wings. Passenger vehicle lighting is much as before, but evidently the need has been felt for something better. C.A.V. at the last Exhibition introduced their system of fluorescent lighting which has now

been simplified and improved. The old system employed a rotary converter driven from the 24-volt system and generating alternating current at 110 volts 380 cycles. This method, of course, overcame all the well-known difficulties as regards operating the lamps. They have now introduced their new "Fluorostatic system" which permits the use of the normal 24-volt body wiring and eliminates the rotary machine.

Each lamp is fed by its own "power unit" which comprises essentially a simple vibrator choke unit. The new system will be very much less expensive and operates at the high efficiency of about 85 per cent. Long tube life with freedom from end blackening is claimed for the new system. Overall figures for the efficiency of the system using fluorescent lighting compared with those obtained with tungsten lighting show a gain of 180 per cent. so that for the same input about 2.8 times the amount of light is produced. As each fluorescent tube has its own power unit, switching whether singly or in groups of lights will present no difficulty and existing systems of wiring can be used. The result of a failure would affect one point only and not the whole lighting system, as would be the case with the converter system.

Taking as a typical case that of a vehicle using twenty-seven 15 watt lamps, the power required will be 400 watts. One "Warm White" fluorescent tube of 14 watts rating when operated through the C.A.V. Fluorostatic system of 85 per cent. efficiency will require 16½ watts so that 24 tubes could be used for a D.C. power consumption of 400 watts. The fluorescent tubes at 40 lumens per watt would give $40 \times 24 \times 14$ or 13,400 lumens. The tungsten lamps at 12 lumens per watt will only give 400×12 or 4,800 lumens, so that for the same expenditure in watts it is possible to obtain 2.8 times the light or conversely nine fluorescent tubes with a D.C. consumption of 150 watts will give the same light. If maintenance charges are not excessive it would seem that a system of this kind has considerable advantages.

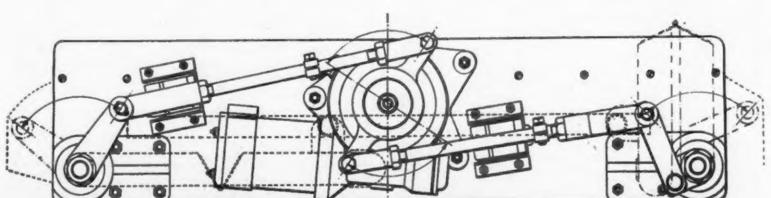


C.A.V. control box on Albion "Clydesdale" chassis.

C.A.V. show an electrically operated door gear for public service vehicles which is suitable for sliding, gliding or folding type doors. The mechanism is operated by a small motor with worm reduction gearing, a friction clutch being interposed between it and the levers operating the doors. Should any obstruction be encountered by the doors, the clutch will slip and prevent accident.

The Scintilla Company show a motor generator unit type U.A. 103 with an output of 750 watts. It is designed to operate from a high line voltage and the particular model shown is for railway use. The motor and generator units are in consequence insulated from one another both as regards the frames and armatures. Both machines are bolted to a rectangular central chamber through which air is admitted for cooling. The outer end of each armature carries a fan and discharges air through a cowl surrounding each fan. The whole unit is designed for suspension in any convenient position and the mountings are rubber insulated to prevent noise. The motor is compound wound and the generator shunt wound, operating in conjunction with a normal control box of their XG type. The box contains the usual cut-out and voltage regulator but it is of interest to note that the voltage control is in four steps.

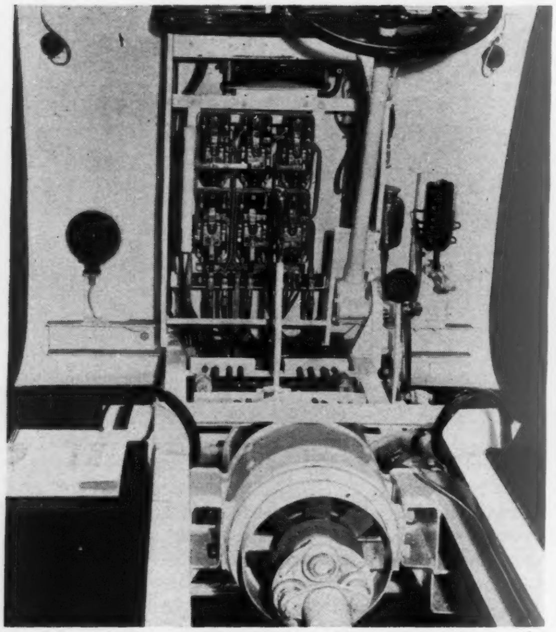
The new C.A.V. direction indicator is of the self-cancelling type and has an internal warning light which shows through the red plastic cover carrying the operating knob. Movement of this knob in either direction switches on the corresponding indicator and also the warning light. A time delay switch is incorporated which returns the knob to the central position after an interval of 5 to 20 seconds, which is adjustable. The delay mechanism is of the pneumatic type with diaphragm dashpot, and has an adjustable air leak. The diaphragm is depressed by a rocker arm operated by the control knob against a spring, expelling the air through a non-return valve from the dashpot chamber below the diaphragm. When the knob is released the switch returns slowly to the central position under the action of the spring as air flows slowly back to the dashpot chamber through a small orifice. The size of this hole is controlled by a screw regulating the delay as required. The switch warning light and the direction indicator bulbs are in series, so that the warning light is only illuminated when the arm is fully raised.



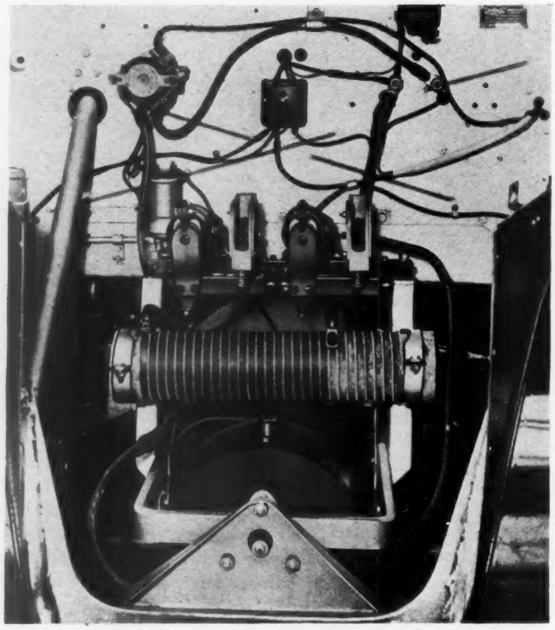
C.A.V. electrically operated door gear for double jack-knife doors.

The new T type direction indicator designed for commercial vehicle duty is flush fitting and mounted in an aluminium pressure die casting. The arm has a spring controlled hinge permitting lateral deflection of the outer part up to 40 deg. on either side should an obstacle be encountered. Flexible leads round the hinge have been replaced by silver plated wipe contacts. Owing to the size of the arms two bulbs connected in parallel are fitted to each arm. The whole design is exceedingly robust and every care has been taken to render it weatherproof.

The N.C.B. electric 30 cwt. chassis shown by Smith's Electric Vehicles Ltd. has a frame of conventional design with straight side members and semi-elliptic springs at front and rear. The side members are closer together



N.C.B. electric vehicle, motor and control gear.



Electrojan motor and control gear.

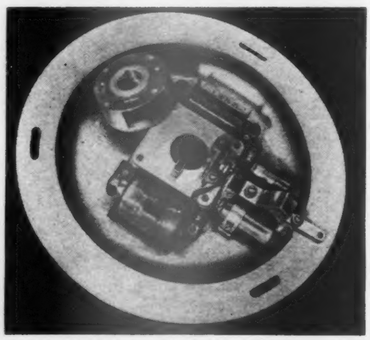
than usual as they carry half the driving battery on each side in suitable cradles, designed to facilitate inspection or removal when required. A 12½ h.p. fan-cooled B.T.H. series motor is mounted between the side members and under the driving seat. The drive is taken from the motor by a propeller shaft to the double reduction back axle which has a helical first and spiral bevel final reduction and an overall ratio of 12 to 1. The tyres used are the standard pattern and not the special type generally used on electric vehicles. They are 27in. × 6in. and fitted to 15in. rim diameter steel disc wheels.

The electrical control is by B.T.H. standard controller, which is pedal operated, and solenoid operated contactors. These, in conjunction with push button control, connect the two halves of the battery in series or parallel, inserting resistances as required in the circuit to give the first and second stages in both series and parallel operation. The whole electrical control gear for operating the vehicle is mounted on the nearside of the vertical dash board and completely enclosed by a removable cover.

Lockheed hydraulic brakes operating on 12in. drums are fitted to all wheels and in addition there is a mechanical hand brake connected to the rear wheels. The motor is not used at all for braking. A 226 ampere hour battery of 36 cells is used which gives from 25-30 miles running under normal average conditions. A Legg metal rectifier charger complete with relay for automatic operation is part of the equipment.

The "Electrojan" commercial electric vehicle has been introduced by Trojan Ltd. as an alternative to the petrol vehicle and the minimum amount of alteration has been made to the general design of the chassis. The standard gearbox is used and an electric motor held in a special cradle designed to join up with the front end, takes the place of the engine.

The motor is a series wound 60 volt machine capable of delivering 8 h.p. for 1 hour without exceeding the B.E.S.A. temperature rise. The control is in two stages operated by the accelerator pedal and a single resistance carried in the bonnet above the motor. The 60 volt battery has a capacity of 175 ampere hours and is divided into two sections which are carried in cradles on each side of the main frame members. These cradles are designed to slide outwards on rollers from under the body when the covers are removed so as to facilitate service on inspection.



Scintilla crankshaft magneto.

The top speed in the gearbox is blocked so that the vehicle has a two speed and reverse gearbox combined with the usual clutch. As the change from electric to petrol can be effected without much difficulty it is possible to utilise the same vehicle for the different operating conditions.

The Lucas SR type of light-weight magneto which was introduced recently as a single-cylinder model has now been developed and is available in models suitable for single, twin and four-cylinder engines. It is of extremely simple construction, the body being formed of a single aluminium die casting having the cores and pole pieces cast in position. A moulded cover completely encloses the mechanism. It is primarily designed for small stationary engines.

The Scintilla Company show a new magneto, model N.D.K., which is designed for small tractors or cultivators which may be required to work at night and in consequence the magnetic circuit includes another coil which gives 12 watts at 6 volts A.C. The machine is designed for a single-cylinder two-stroke engine and uses the same four pole rotating magnet as the Vertex magneto. If driven at crankshaft speed with a single cam only, two poles of the magnet would be required for ignition but the four poles are most desirable for the lighting circuit.

FRONT AXLES AND STEERING

Power Steering on Heavy Duty Vehicles

THERE is very little change in front axle design at this year's Show. A position of almost complete standardization in design has now been reached. Every axle in the Show was of the reversed Elliott type. Most of them have plain bushes, often with chromium plated pins, and on the lighter vehicles thrust washers of lead bronze or similar material in between steel plates are frequently employed. On some bus chassis thrust buttons in the bottom cap are used, while a few designers continue to employ taper roller bearings to take the end thrust at the top of the swivel. Presumably with the idea of keeping the track rod arms as far off the road as possible to give ground clearance, most bus designers prefer to use a cranked track rod instead of lowering the arm and ball pin so that a straight track rod will pass under the front spring. The term "cranked" is perhaps a misnomer, as the effect is always obtained by offsetting the end stampings which carry the ball sockets. At the same time it should be noted that although the tube is not bent, the effect is there just the same and the track rod is rather more elastic than would seem desirable. Self-adjusting ball joints, such as the Thompson eccentric tie rod are very common. On the new Bedford 7-tonner ball joints are used in which the adjustment though taking effect at right angles to the pin axis, as in the Thompson tie rod, is formed by split conical wedges forced axially down a parallel hole in the eye over similarly split conical sockets embracing the ball pins. On some of the trolley bus chassis with considerable front overhang, the designers have now managed to connect the steering box to the front axle by a single rod without the cross shaft and intermediate levers still to be found on one example.

The various well-known types of steering gears were all represented, the Marles double roller gear being particularly popular, while firms such as A.E.C. and Dennis continue to use the screw and nut gears which they themselves have developed. Fodens continue the recirculating ball steering gear which was brought out at the last Show, and the lighter vehicles have the simpler forms of cam gear common on pleasure car chassis. On the new 7 ton Bedford the steering column is carried in two spring-loaded cup and cone ball bearings in a short tube supported by a bracket off the facia board by a rolling rubber ring, compressed into an annular space. The lower end of the column spindle is connected to the box by a fabric universal joint. Among the many advantages of this system is that relative movement of the cab is possible without straining the steering column, and much of the vibration normally felt by the driver is damped out by the fabric universal joint.

Steering and control unit on Dennis "Dominant" chassis.

Power steering is to be found in several instances. One Daimler bus chassis is fitted with Lockheed hydraulic servo steering, first exhibited at the last Show. The design of this mechanism is particularly commendable and will bear re-description. The steering column spindle has a screw thread at its lower end which engages a nut connected by a ball thrust bearing to a two diameter piston sliding in a hydraulic cylinder and in its turn connected by a link to a lever on the drop arm spindle. The nut, being rotationally free of the piston, tends to turn with the steering wheel. This motion is transmitted by gear teeth to a swinging lever which operates the hydraulic control valve. The action of this is very much sweetened by the fact that the working piston is a differential one. Its smaller face is continuously connected to the pressure supply, while its larger face is alternately connected to the pressure or to exhaust, according to the direction of movement required.

It will be understood therefore that the control valve only has to open one passage and close another instead of having to deal with two sets of valves at once, as in the case of a steering gear where a reversal in the direction of motion involves changing one end of the cylinder from pressure to exhaust and the other end from exhaust to pressure. The whole mechanism being housed in the steering column casing makes a very neat unit with no external pipe connections excepting those for the supply and return of fluid connected to the pump and accumulator system.

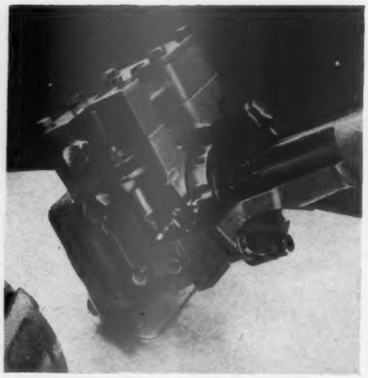
On the Thornycroft "Antar" with its front axle weight of 9 tons and use under cross-country conditions, power steering is an obvious necessity. It may be mentioned, incidentally, that the Kirkstall front axle is stamped solid instead of I section, this again being a sensible precaution on a machine where the driving bogie weight is 36 tons and which is quite capable of bending back an I section front axle by sheer driving power, quite apart from impact stresses. On this machine the steering box mounted on the left-hand side of the vehicle, has its drop arm connected by a short rod to a slave lever the lower end of which carries a long drag link connecting to a

Solid section Kirkstall front axle of Thornycroft "Antar" chassis.

steering arm on the axle. The upper end of the lever is loosely fitted around a fixed pin, being supported by hanging links from it. The slight amount of fore and aft movement which the lever can make about the pin operates double acting hydraulic control valves, the lever layout being very similar to that of a Clayton Dewandre vacuum servo.

An interesting feature is that the hydraulic control valves are connected to two opposed cylinders on the other side of the vehicle, their piston rods being pin jointed to a swinging lever anchored at its upper end to the frame and connected by a ball pin at its lower end to a drag link working a steering arm on the right-hand swivel of the axle. It provides therefore a rather unusual but eminently sensible layout in which the hand steering gear is connected to one side of the axle and the hydraulic to the other, an arrangement that tends to distribute to some extent the shocks caused by any violent impact.

The Scammell cross-country vehicles were fitted with a compressed air servo developed by Clayton Dewandre. What might be described as a bevel differential is interposed between the



Clayton-Dewandre compressed-air steering servo control valves.

steering column and the cam spindle in the steering box. The centre bevel rotates on a pin that can swing laterally to a small degree about the axis of the column spindle. Movement of the steering wheel to right or left therefore causes in initial stages, a corresponding movement of half the amount of the central bevel wheel and a lever on its spindle operates the compressed air valves. The steering box has, of course, to be made of the opposite hand to normal on account of the reversing action of the bevel gearing. The drop arm of the steering box is connected by a drag link to a hanging lever from the lower end of which another drag link goes forward to the steering arm on the axle, while just behind it there is coupled to the lever a double-acting air cylinder connected to the control valve on the steering box.

The new Leyland "Tiger" underfloor engined chassis is unique in having a divided track rod connected to a central lever supported by the front axle and in its turn connected to the steering gear. It is claimed that this arrangement very much reduces the effect of road shocks. This is probably due to the fact that there is not the direct connection between one front swivel and the steering box that exists in an ordinary vehicle. Thus, with normal right-hand steering an impact on the right-hand wheel is severely felt by the driver, while one on the left would be cushioned by the spring of the track rod arms. In the Leyland arrangement neither wheel is directly connected to the steering gear and road shocks from either side are to some extent cushioned.

R3

CENTRELESS GRINDING

An Interesting Development on Scrivener Machines

DURING recent years Arthur Scrivener Ltd., Tyburn Road, Birmingham, have been responsible for many interesting developments in centreless grinding technique. One of the most recent relates to plunge-ground form work, employing two pairs of wheels on a single machine that incorporates full automatic operation. Two types of 2-diameter studs are required in the automobile industry in very large quantities and in approximately the same numbers. This demand raised the question whether both types could be ground simultaneously on the same machine.

For this purpose, a Scrivener No. 2 controlled-cycle machine was fitted with two pairs of grinding and control wheels, 2 in. and 1½ in. wide respectively. Each two grinding wheels and each two control wheels are arranged to be trued to the required form from the same hydraulic truing slide. The difficulty of loading the workpieces on to the work plate in the space available, which is necessarily very restricted, has been overcome by the adoption of an automatic magnetic loading device.

Workpieces of each type are loaded by hand on to the appropriate inclined chute and roll by gravity to the lower end to be retained by a hook. Transfer of the lowest workpiece to the workplate between the wheels is effected by a vertical arm carrying a magnet which is raised and lowered by the operation of an hydraulic cylinder. This movement is synchronised with the controlled-cycle mechanism for advancing and withdrawing the control wheel for each plunge-cut cycle.

At the start of the cycle, the magnet is energised and picks up the end piece from the chute. On the downward movement to place the work on the workplate, the arm depresses a hinged support to allow the next piece to roll down to the retaining hook. On the return, or upward, stroke, of the arm, the hinged support is again raised to interpose a pin between the lowest piece and the rest of the line of workpieces.

When, under the influence of the hydraulic cylinder, the piece has been placed on the workplate, the magnet is de-energised, the controlled-cycle mechanism advances the control wheel and the work on to the grinding wheel. As soon as the work is ground to size, the wheels open to a sufficient distance to allow the ground piece to fall between the grinding and control wheels.

Ejection of the work by allowing it to fall between the workplate and the control wheel is one of the incidental advantages of the controlled-cycle method. This cycle permits a very wide wheel withdrawal when necessary.

In connection with the ejection of the work there is a further refinement on this machine. It takes the form of a wiper arm that sweeps each ground piece into the appropriate work container. This wiper arm is operated by means of a bracket on the magnet arm. The arrangement is such that the magnet arm on its downward stroke depresses a spring-loaded plunger operating in a sleeve that has a helical slot. Movement of the plunger in the slot causes the wiper arm to move forward and eject the finished work. With a fairly heavy stock removal in the order of 0.010 in. the grinding cycle is nine seconds and the production is at the rate of 800 pieces per hour, that is, 400 of each type. With a slightly lower stock removal, the production can be at the rate of 1000 pieces per hour.

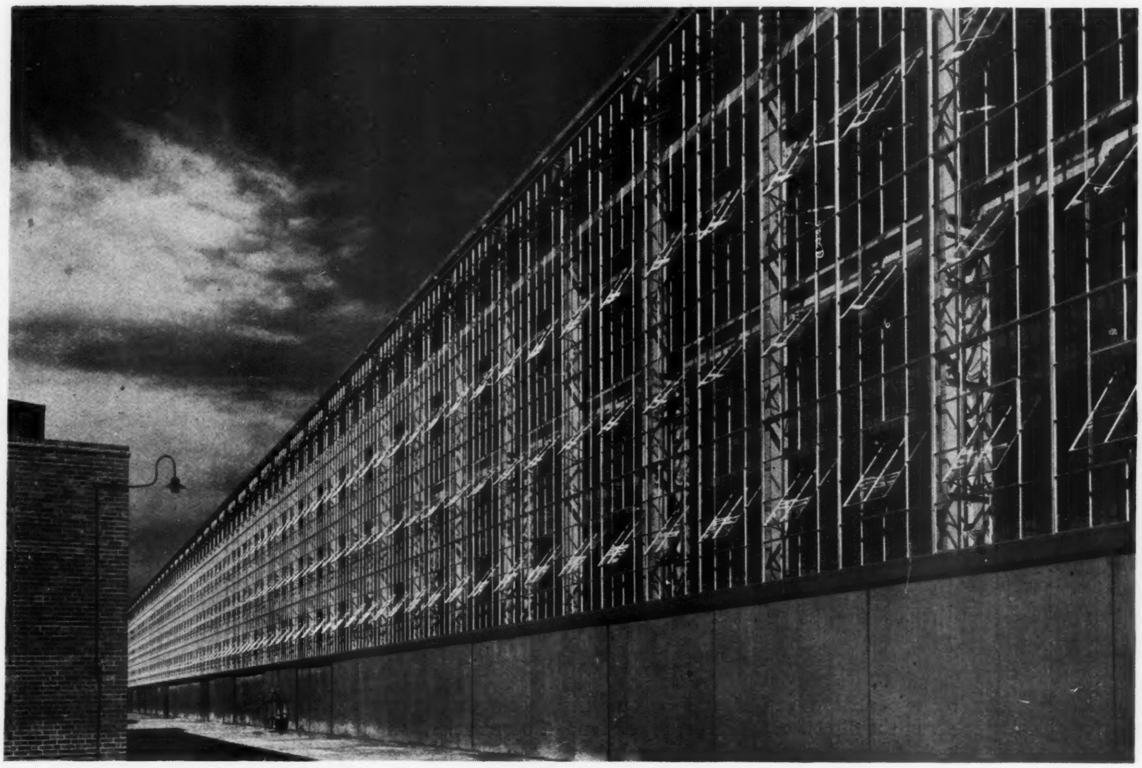


Fig. 1. The press forge department at the Bromsgrove works of J. Garrington & Sons Ltd.

PRESS FORGING

The Equipment and Production Methods Employed by J. Garrington & Sons Ltd.

ALTHOUGH forged steel components are basic products for almost every branch of engineering, it is no exaggeration to say that in many forging organisations there is little apparent difference between the equipment and methods used to-day and those of thirty or forty years ago. There have, of course, been considerable improvements in product quality through the more scientific application of metallurgical knowledge and the use of better machines and tools, particularly multi-impression dies. Nevertheless it remains true that in appearance and general methods there is little to differentiate many forges from those of forty years ago.

What advances can be made however, is shown in a striking manner by the developments carried out at the Bromsgrove Works of J. Garrington and Sons Ltd. At these works, the lay-out and the equipment employed compare favourably with those of any other forging organisation in any country, including the United States of America.

In two factories, one at Darlaston and the other at Bromsgrove, there are facilities for producing a wide range of high quality steel forgings. So far as the automobile industry is concerned, it is possible to produce all the forgings necessary for passenger cars, commercial vehicles, trucks and tractors. These include such parts as small rocker arms weighing only a few ounces, up to the largest crankshafts weighing 1½ cwts. It was, in fact, to meet the demands of the automobile industry that the developments of the past three or four years were undertaken.

In practice, every type of machine forging is carried out. The equipment therefore includes board hammers, friction hammers, air-operated hammers and vertical hot-forging presses. Which type of equipment is employed for a specific application depends upon several factors that lie outside the scope of these notes. There is, however, little doubt that in future, increasing use will be made of upset forging machines and vertical hot-forging presses, and less work will be done on the various types of hammers. This applies particularly to forgings required in large quantities to fairly close limits of accuracy.

This wider use of upset forging machines and forging presses is a logical development, in that the quality of the product is much less dependent upon the skill of the operator. In fact, manual dexterity rather than skill is called for. In hammer forging, despite the use of multi-impression dies, the skill of the hammerman is still an important factor, whereas in the production of forgings on either presses or upset forging machines, the skill is concentrated in designing and making the dies. The operator has merely to place the material in the correct relation to the die at each successive impression and operate the press to give one stroke at each stage. Incidentally, not only is there complete uniformity of product independent of operational skill, but in addition, the output rate is much higher since at each impression there is only one stroke, whereas in drop forging there are many. It is with the Company's developments in press

Fig. 2. A complete set of press forging tools.

forging technique that these notes are chiefly concerned.

Before dealing in detail with the press forging equipment, it is perhaps worth while to discuss briefly the general policy of the Company and more particularly the policy in relation to the automobile industry. It must be stressed that the production of both drop forgings and press forgings is a highly specialised industry, and it is doubtful whether any engineer outside that industry can appreciate the difficulties that may be experienced in making the metal flow in the direction necessary to produce the required form. For this reason, the forging specialist should be consulted at the earliest stage of design.

Because of the importance of correct design, J. Garrington and Sons Ltd. offer a complete advisory service. It is probable that the best approach would be to give the Company all relevant information concerning the function for which the forging is intended and the stresses it will meet in service. From this data the forging specialist should be allowed to prepare the design and select the material. This, however, is probably a counsel of perfection, and unfortunately it is not easy to demonstrate the value of such an approach. Valuable highly specialised knowledge is however available, and should be used to the full. In the case of forgings that have to be machined, the machining methods should be specified, since they may affect the design. Co-operation on this point will often eliminate the danger of machining difficulties, particularly if the forging is to be mounted in a jig.

How far the policy on design is accepted is a matter for the users of the Company's products. Similarly, how far advantage will be taken of the production policy depends in great degree on the measure of co-operation. J. Garrington and Sons Ltd. get from users of their products. So far as the automobile industry is concerned, the production control system has been so re-organized that supplies can, if desired, be made in relatively small quantities and at fairly high frequencies. This can be a great convenience and saving, since it means that stocks and stock investment can be kept at low levels. It is worth pointing out that from the Company's standpoint this policy has certain drawbacks, since it entails more frequent tool changes. It also calls for much closer production quantity control than is normal in forging organisations. Nevertheless, it is undertaken to ensure regular supplies according to the user's requirements.

At least one major automobile manufacturer has found it advantageous to place orders for complete sets of forged components. To some this may seem a dangerous policy since

Fig. 3. The steel stores for the press forge.

it places reliance upon a single source of supply, but the danger is more apparent than real. There is, of course, a remote possibility that some catastrophe would cause a complete cessation of supplies. But against this remote contingency there may be placed the certainty of balanced deliveries. There is a much greater danger of interruptions in production through lack of balance when the supplies are obtained from several sources than there is that a single well-organized firm will fail to meet requirements.

Another point in the Garrington policy is full co-operation with the user's inspection staff. This could be greatly extended to the benefit of both the supplier and the user where the quantities involved are sufficiently large. It is now recognized, though not always practised, that materials should be handled as little as possible. Therefore, the best point for user inspection is in the producing factory. In this matter, the Company are prepared to give full co-operation.

No matter what forging technique is employed, the most important factor is die design. This is a matter that falls outside the scope of these notes, but die design is not only a vital factor in product quality; it is also important in the economics of forging production. On the average, material charges represent nearly 50 per cent. of the total production costs. It is therefore, essential that the die design be such that the amount of trimming after the component leaves the hammer or the press, is as low as practicable. Furthermore, design can have an important effect on die life.

Die Making

Dies for the whole of the two factories are produced in a very well-equipped die shop. The actual machining methods vary according to the type of die, but they are in the main conventional and therefore call for little comment. In general, the dies are made from a special alloy steel that is supplied in the hardened and tempered condition. Its tensile strength is in the order of 85 tons/sq. in. It is therefore, much more difficult to machine than the materials that are worked in the normal machine shop.

Although the actual machining methods follow normal practice for the production of forging dies, reference must be made to the fact that contrary to usual practice, it has been found possible to set standard synthetic times for the production of all dies. This has been made practicable as a result of a comprehensive study of the machining conditions, particularly speeds and feeds. It is of interest that in several cases, reductions in speeds and feeds gave increased production. Since the introduction of standard times, die production has greatly increased. This is important, as the capital outlay for a set of dies is heavy and consequently the aim of the Company is to keep die investment to a minimum. The ability to produce dies quickly and with a guaranteed delivery date has been of great service.

Fig. 4. A large hot-cropping machine.

When a set of dies is finished, a cast is taken of the die form. A special metal that does not shrink on cooling is used for this purpose. The casting is then fully checked for dimensional accuracy. If the die satisfies this test, specimen forgings are then produced. These are also tested for dimensional accuracy. In addition, they are tested to ensure that the forging operation has not created undue residual stresses. Finally, they are sectioned at critical places and examined for grain flow. A set of press forging dies is shown in Fig. 2.

The Press Forge

It is in the press forging department at Bromsgrove that J. Garrington and Sons Ltd. have made the greatest break from traditional practice. This applies to the building itself, to the lay-out, and to the equipment. Few will dispute that a forging department is usually a gloomy place with rather unpleasant working conditions. In planning the new department, the

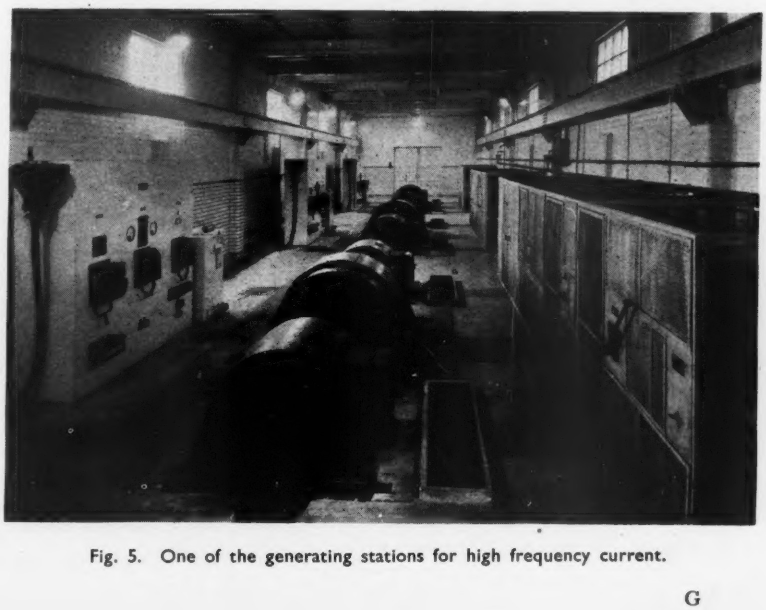


Fig. 5. One of the generating stations for high frequency current.

Company decided there was no reason why a press forge should not be as light and airy as other modern engineering shops. The external view of the department, shown in Fig. 1, shows the degree to which they have succeeded.

The building is in the form of an L, with the upright comprised of three bays 550ft. long and the base of a bay 420ft. long and 70ft. wide. Each side of the building is glazed completely down to a point approximately 10ft. above ground level. In all, there is approximately 63,000 super feet of glazed surface so that the maximum benefit is obtained from natural lighting. Some 25 per cent. of the glazed area consists of electrically operated opening frames.

The factory has been laid out to give flow production from the raw material storage section to the road and rail despatch bays. Briefly, the lay-out is, raw material storage and cutting-off sections in the transverse bay, press forging units in the outer longitudinal bay, and heat-treatment furnaces, coining presses, shot-blast plant and the inspection section in the central longitudinal bay. The third longitudinal bay is not at present used, but it will eventually house either upset forging or vertical press forging machines.

Raw material is delivered direct to the storage section, see Fig. 3, from which it goes to the appropriate cutting-off section by overhead crane. Three methods of cutting-off are employed, cold cropping, hot cropping and sawing. As far as possible, the material is cropped to billet size, since cropping is quicker, cheaper and makes fuller use of the material than sawing. Cold cropping can be carried out only on the softer materials of the mild steel class. The greater part of the press forging production is from high grade alloy steel that are much too tough for cold cropping. Therefore special plant has been installed for hot cropping. It comprises two specially designed Priest gas furnaces of the continuous type and four cropping machines. The largest cropping machine is illustrated in Fig. 4.

Stock is delivered to these furnaces by overhead crane and is conveyed through the furnace at a controlled rate by a hydraulic pusher mechanism. After the pre-determined period in the furnace, the bar emerges at the other end and falls down an inclined ramp into a trough. It is then raised by hydraulically-operated mechanism for transfer to a roller conveyor that serves two cropping machines, one at either end. The complete arrangements for hot cropping have been designed to allow a small number of operators to handle a large weight of material without undue fatigue. To make the utmost use of the material, bar ends from hot cropping are transferred to the sawing section for cutting-off to billet length.

Rating and Output Capacity of High Frequency Heaters.

Rating kW.	No. of heaters	Dia. of hearth	Billet section ins.	Output per hour per heater lb.
150	6	4ft 6in	1—2	900
250/300	3	5ft 6in	$1\frac{3}{4}$—$2\frac{1}{2}$	1500 to 1800
400	2	5ft 6in	$2\frac{3}{4}$—4	2400
800	1	7ft 6in	$4\frac{1}{2}$—5	4800

Press Forging Units

So far as equipment is concerned, the outstanding feature of this department is the use of high frequency induction heating to bring the billets up to forging temperature. Essentially, a press forging unit comprises a high frequency induction heater, a forging press, a trimming press and the necessary ancillary equipment such as compressed air lines for blowing out dies. At present there are 12 forging presses in the department. The types and the approximate maximum tonnage pressures are :—

1—No. $7\frac{1}{2}$ Maxipress :	5,000 tons
1—No. 6 Maxipress :	2,000 tons
1—No. 20C Ajax :	2,000 tons
3—No. 4 Maxipress :	1,000 tons
4—No. 3 Maxipress :	800 tons
2—5C Ajax :	500 tons

For each press there is a heater unit

Fig. 6. Part of the press forge department.

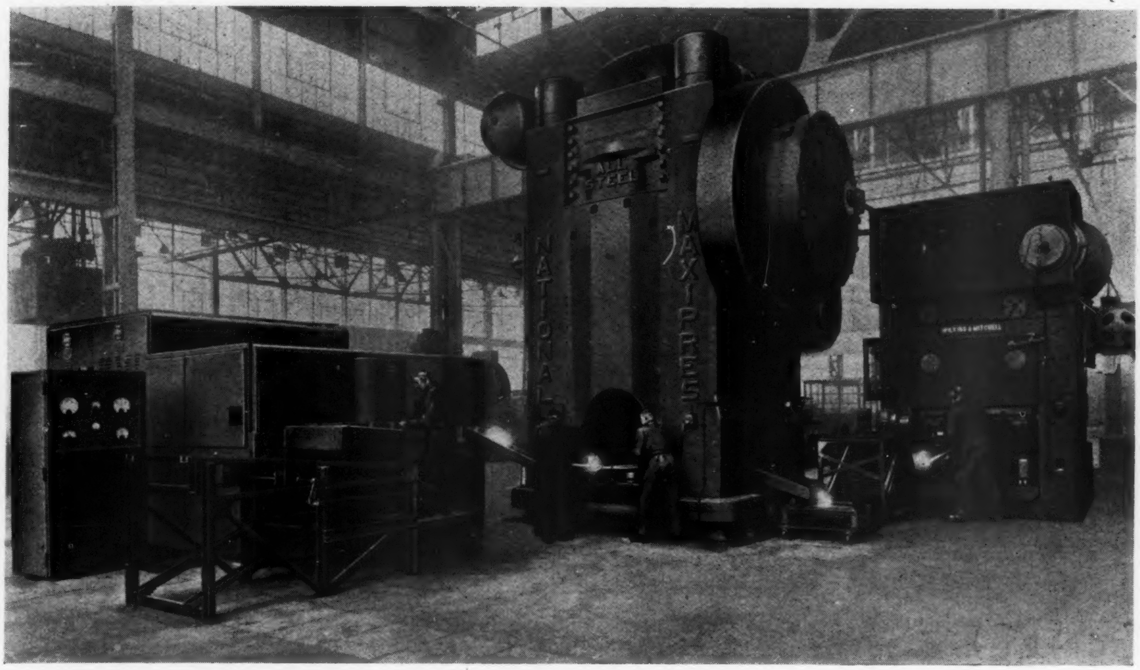


Fig. 7. 800 kW induction heater, 5000 tons forging press and trimming press.

consisting of a rotary hearth passing through a skate coil. The hearth is driven through a variable speed gearbox. Each of these heater units is designed for heating billets. For use in conjunction with the No. 7½ Maxipress there is a second high frequency induction heater designed for heating bars from which crankshafts are pressed.

This application of high frequency induction heating differed greatly in degree and appreciably in kind from anything that had hitherto been undertaken commercially. Finally, the design and construction of the several heaters were undertaken by Birlec Ltd. and the Electric Furnace Co. Ltd. in collaboration. The accompanying table gives the capacities of the various units.

Special generating equipment has been installed to supply the power for the heaters. Two frequencies are employed, 3kc/sec. for the heaters for the six larger presses and 10kc/sec. for those used with the six smaller presses. The necessary equipment is housed in two generating stations. One station is shown in Fig. 5. In each station there are three machines comprising two generators coupled to a common motor. The 3kc machines are Metropolitan-Vickers and are fed direct from an 11,000 volt supply. The 10kc. motor-generators were made by The British Thomson-Houston Co. Ltd. For these, the motors are fed through step-down transformers at 400 volts. To maintain a constant output voltage under varying conditions of operation, each generator has series condensers and automatic controls.

Of the three 3,000 cycle motor-generators, one feeds the heater for the No. 7½ Maxipress, the second feeds those for the No. 6 Maxipress and the No. 20C Ajax, while the third feeds the heaters for the three No. 4 Maxipress. There are certain differences in these three generators because of the different powers to be supplied to the heaters. That serving the No. 7½ press has all the windings in parallel to give the maximum output of 800kW; that for the two 2,000 tons presses has the two windings of each half generator connected in parallel; that for the three 1,000 tons presses is designed with two half generators running individually on two stations and in parallel on the third. This allows the heaters to be run at either 250 or 300 kW output to suit the work that is being handled. Each generator of the 10,000 cycle equipment serves a single heating station in such a manner that the individual loading of a station is controllable downwards from a maximum of 150 kW. A general view of the forging press line is shown in Fig. 6.

With the exception of the bar heater used in the production of crankshafts, the heating units are all constructed on the same principle. Basically, each

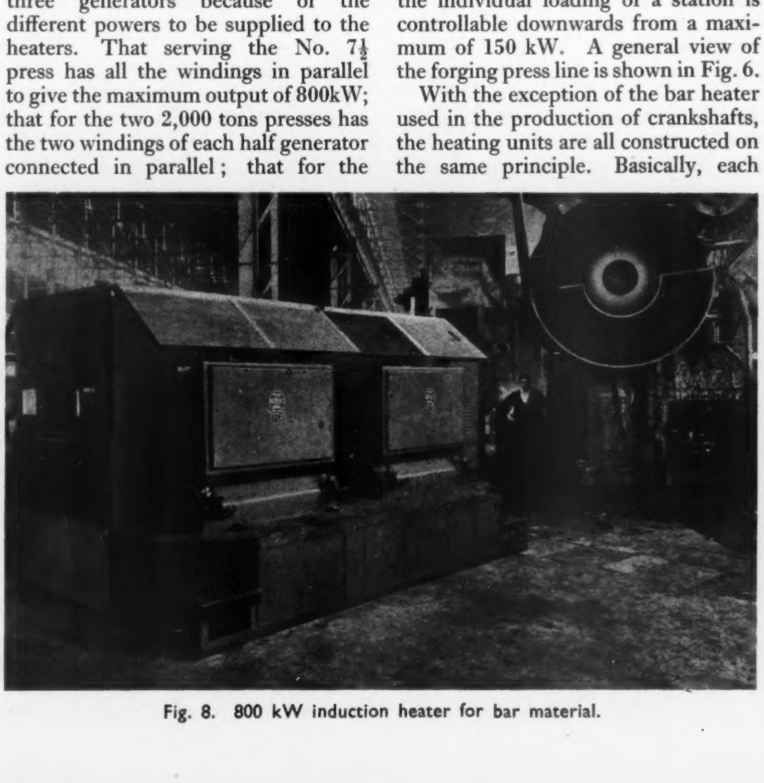


Fig. 8. 800 kW induction heater for bar material.

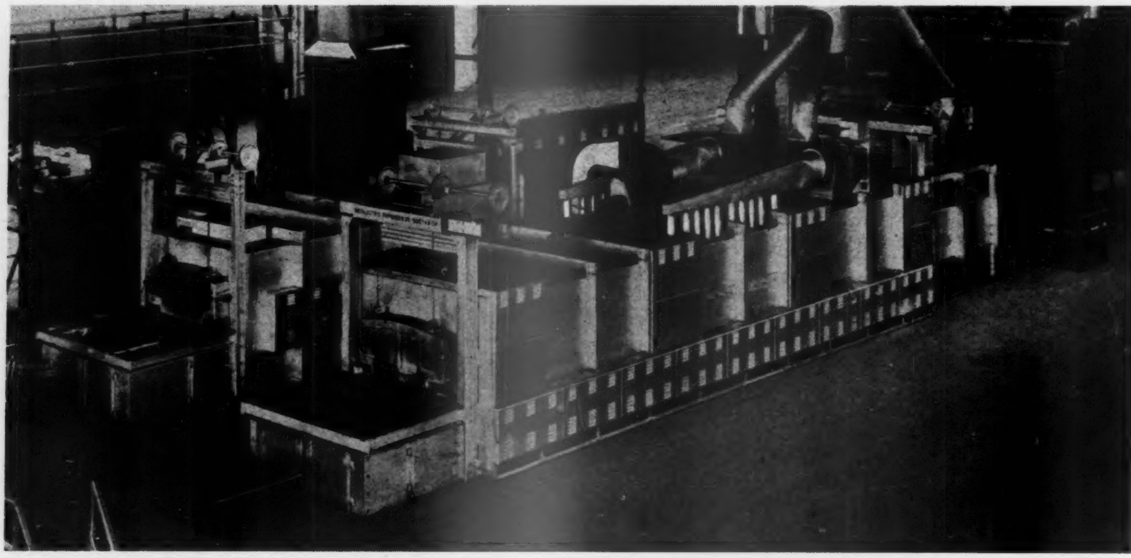


Fig. 9. Heat treatment furnaces in the press forging department.

unit comprises a turntable for carrying the billets and a channel coil for heating them. The turntable, which supports a refractory hearth, is driven by an electric motor through a variable speed gearbox. A special mechanical device is incorporated in the final drive. It automatically declutches and switches off all power should there be undue resistance to rotation. Each turntable incorporates a loading device to ensure that the billets are correctly positioned and will pass freely through the heating coil.

As is well known, the normal practice in induction heating equipment is to use helical coils, but in these applications channel coils are used. This form has several advantages for this class of work. It can be more robust, lends itself more readily to mechanical ejection of the work and simplifies maintenance problems.

Since every heater unit has to cover a range of billet sizes, there is also a range of coils designed to deal with billets increasing in size by increments of $\frac{1}{4}$in. This is essential for working the equipment at optimum efficiency. Every coil has its own supporting framework and has been specially designed to allow changing to be effected quickly. Actually, a change-over of coils can be effected in less than half-an-hour, less time than is taken in changing the press dies.

Close control of all relevant factors is a fundamental necessity in induction heating. Broadly, the temperature the work will reach is a function of the time it takes in passing through the coil and the power input to the coil. These factors are determined for every application and the controls are pre-set to maintain them automatically. Only in respect of the correct spacing between successive billets is any reliance placed on the operator.

For this type of application, high frequency induction heating has proved to have several advantages over the methods hitherto employed in respect of work quality, production economics and working conditions. The chief advantages are :—

(1) Improved quality of work.

(2) Much quicker heating to forging temperatures. A $1\frac{1}{4}$in. square billet is brought to the forging temperature in 45 seconds whereas with conventional furnace heating some 10 minutes would be necessary.

(3) As a result of reduced scaling, the wear on the dies is reduced.

(4) The forging temperatures are automatically controlled.

(5) Overall operating costs are at least comparable with conventional furnace heating. An induction heater is ready for use within a few minutes after the power is switched on, whereas with a furnace a lengthy heating up period is necessary. It is therefore practicable to switch off the power for short periods, such as meal hour breaks.

(6) Since there is virtually complete freedom from fumes and the heating plant does not affect the shop temperature, working conditions are greatly improved.

An extremely compact lay-out has been adopted for each forging unit. The lay-out for the largest is illustrated in Fig. 7. Briefly, the forging press is in front of and to the left of

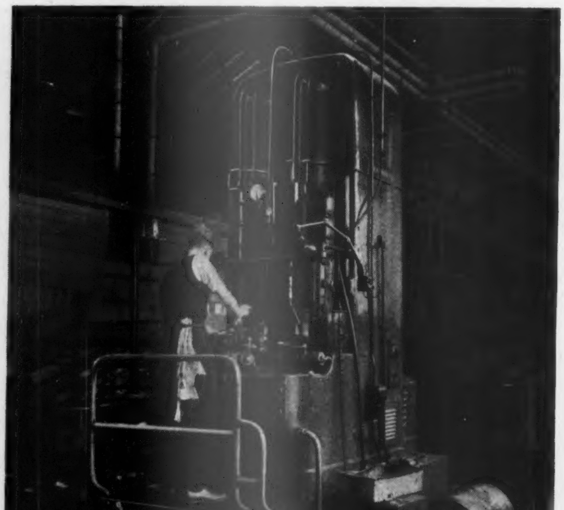


Fig. 10. Surface broaching in the hand tools department.

the heating unit, and the trimming press is in front of and to the left of the forging press. Provision is also made for transferring the work from the heater to the forging press and thence to the trimming press in such a manner that the various operators have no need to leave their stations.

Billets are transferred from the cutting-off section to the forging section by fork truck. They are there loaded on a storage platform conveniently situated in relation to the loading station for the heater unit turntable. At the completion of its travel through the channel coil, the billet is at forging temperature and is automatically ejected into an inclined chute for delivery direct to the forging press. When forging is completed the billet is automatically ejected from the side of the press into an inclined chute to fall on to a short endless conveyor for transfer to the trimming press. The induction heater for bar material is shown in Fig. 8.

Although press forging has been employed for a good many years, there is still inadequate recognition of the possibilities and potentialities of the process. Present-day drop forging technique is such that remarkably close tolerances can be maintained, if necessary, but with press forging much closer tolerances are possible. For example, J. Garrington and Sons Ltd. have produced gears that could be run without any machining on the teeth. However, although it would not be good practice to use gears as forged for high duty service, there is no reason why such gears should not be press forged so that only a grinding operation is necessary. If this practice were adopted, the savings in overall costs and in production times would be considerable. Incidentally, it may be pointed out that the use of high-frequency induction heating, with the consequent freedom from scale on the work, is an important factor in the production of forgings to close tolerances.

Although press forgings can be and are produced to very close tolerances, it should be stressed that this is not an adequate reason for specifying very close tolerances. It is still economically important that the widest possible tolerances be allowed.

From the forging and trimming presses, the work is transported to a marshalling section in the middle bay of the shop. The routing from this point depends upon the class of work. In addition to the inspection section, this bay includes equipment for heat treatment, three 750 tons coining presses for setting forgings when necessary, and two Wheelbrator shot blast machines.

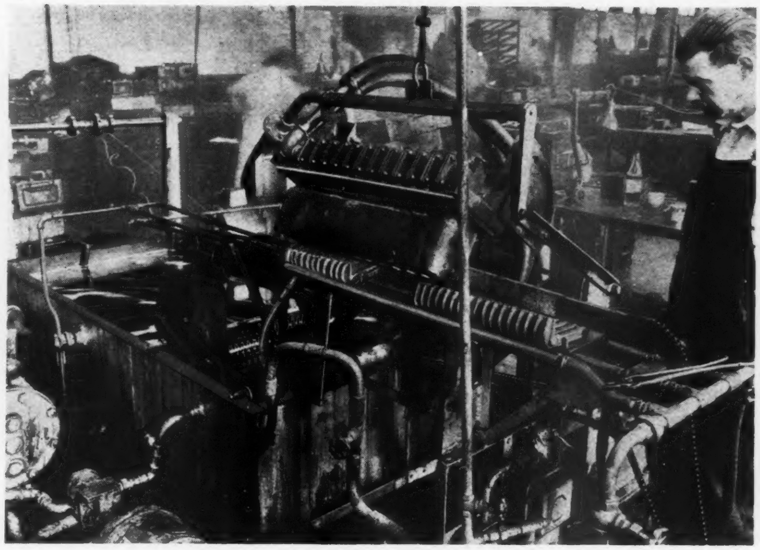


Fig. 11. Special Shorter equipment for hardening hand tools.

A large proportion of the forgings produced in this department require heat treatment. To deal with these forgings there are three furnaces, one for hardening, one for tempering and one for normalizing, see Fig. 9. All three have been designed and built by Metalelectric Furnaces Ltd. The hardening and tempering furnaces are arranged in line to allow a continuous flow of production. They are both of the cast link conveyor type with provision for ejection of the work on to a conveyor for carrying the work through the quench tank. Pusher-type conveying mechanism is used in the normalizing furnace. The work is carried through this furnace on trays.

The chief interest of the Company is the production of forgings for other organizations, but a description of their activities must include a reference, even though brief, to the production of engineers' hand tools. The forgings for these are produced in one or other of the forging departments but the remainder of the work is carried out in a separate department specially equipped for the production of quality hand tools, such as hammers and wrenches. This department is completely self-contained and is equipped for every function necessary. Advanced machining techniques such as surface broaching, see Fig. 10, are employed to give accurate production at high output rates. Provision is made in this department for furnace hardening, salt bath hardening or hardening by the Shorter process, see Fig. 11, and for nickel, cadmium and chromium plating.

In view of the manner in which J. Garrington and Sons Ltd. have developed forging facilities since the war, the following statistics are of considerable interest. The tonnage of forgings produced in 1949 was 10 times greater than that produced in 1939, and the rate of production to-date in 1950 indicates that the target of 15 times pre-war production, representing approximately 25,000,000 units, is likely to be attained.

There has, of course, been an increase in the number of persons employed, but between 1939 and 1949 the productivity per man year increased by 650 per cent. This increased productivity involved large capital expenditure in addition to scientific planning. From it, other industries and the general economy of the country have greatly benefited.

Research Progress

THE Department of Scientific and Industrial Research Report for 1948-49 is now available price 5/6 and is obtainable from H.M. Stationery Office or any bookseller. It begins with a very interesting report of the Advisory Council, which states the broad lines of policy along which the Lord President is being advised. There is also a mass of information on researches in progress and completed at all the D.S.I.R. stations and from all the Research Associations. Incidentally, this is the first time since the war that details of co-operative industrial research have been published collectively.

Summaries are given of a very great number of research investigations on many different subjects, ranging over practically the whole of industry. In the compass of a single volume it is not possible to explain the subjects fully, and the report may best be used as a reference book rather than as an encyclopædia. In most cases, full and detailed information may be obtained only from published technical information or direct from the D.S.I.R. stations or Research Associationsconcerned.

DIRECTIONAL STABILITY

A Study of the Factors Involved in Private Car Design

By G. E. Lind Walker, M.A., A.F.R.Ae.S., A.I.Mech.E.

(*Continued from page* 285)

ANY side wind will always exert lateral force on a moving car which tends to disturb it from its natural course. While conditions remain steady this will probably not be a great inconvenience to the driver. The difficulty for the driver lies rather in the large response of the car to sudden changes in wind forces. Consider the case of a normally proportioned car of frontal area $A = 22$ square feet, and weight 2,500 lb, travelling at 100 miles per hour road speed on a straight course when it is suddenly subjected to a violent side gust wind at 40 miles per hour, at right angles to the course of the car. (Resultant wind speed $v = 1.467\sqrt{40^2 + 100^2} = 158.5$ ft per second at an angle of attack $\gamma = 21$ deg 48 min.) From the formula the side thrust will be approximately

$$F = (0.014 + 0.008 \times 4)\ 22 \times 0.00119\ .(158.5)^2 21.8 = 246\text{lb}.$$

Under these conditions the resistance $R = 263$ lb. Now analysing the behaviour of this car in three different stages of development:

(a) Unstreamlined. The centre of pressure is close to the centre of gravity, and to the neutral steer line.

(b) Simply streamlined. The centre of pressure is now at the front axle.

(c) Streamlined and stabilised. The centre of pressure is located 5 per cent of wheelbase *aft* of the neutral steer line (this 5 per cent is the positive aerodynamic stability margin).

More detailed consideration shows that in case (a) the car will not change attitude greatly, but will be pushed sideways from its original course because of the slip angle of the tyres. From Fig. 2 a slip angle of 0.85 deg would seem probable (side thrust is 1/10th of the rated radial load) thus after 1 second the car will deviate

$$146.7 \text{ Sin } 0.85 \text{ deg} = 2.2 \text{ ft}$$

off its original course.

In case (b) the wind force acts abreast of the front axle, thus all the slip will occur on the front tyres, whose slip angle will be approximately doubled to 1.7 deg, leading to a displacement of 4.4ft of the front of the car or 2.2ft for for the centre of the car off its course after 1 sec. But in addition to this, the car has also been running on a curved path, having now yawed through an angle of

$$\Psi = \text{Sin}^{-1} \frac{4.4}{10} = 21 \text{ deg.}$$

where the wheelbase length of the car has been taken as 10ft. As a very rough approximation this will result in an additional deviation of

$$146.7 \text{ Sin } 21 \text{ deg} = 52\text{ft.}$$

from the original course (total deviation $52 + 2.2 = 54$ft from course after 1 second). However, this deviation would imply a lateral acceleration of $2\frac{1}{2}$ times gravity, and since the side force is only 1/10th of the car weight inertia will limit the displacement to a maximum of about 10ft. The rate of deviation will however increase with time until the driver applies correction.

The aerodynamically stabilised car, case (c) will slip sideways under the initial thrust of the wind, but the rate of deviation in this case will decrease with time until it becomes negative and the car returns towards its original course without the aid of the driver. In this case, with a stability margin of 5 per cent, the displacement at the rear of the car will be 5 per cent greater than that at the front, and the angle of yaw at any moment

$$\Psi = \text{Sin}^{-1} \frac{.05 \text{ deviation}}{\text{wheelbase}} = \text{Sin}^{-1} \frac{.05d}{10}$$

approximately. The car's position at any given time can now be calculated, as shown by Table II. Since in this case the yaw is towards the wind, the deviation due to it is a recovery from the tyre slip.

This calculation indicates a maximum deviation of about 1.5ft at a time 1.5 secs after the beginning of the side gust, and it shows that the car recrosses its original course at between 2 and 3 sect. At this stage it is desirable for the driver to apply correction.

Comparison of these three conditions shows that the simply streamlined car will tend to be seriously disturbed by side winds. The unstreamlined car, of high air resistance, is probably of little interest, but in any case its response to side winds is not violent. The properly designed streamlined and stabilised car shows little immediate response to a side gust, but ultimately requires slight directional adjustment to trim it to the new conditions. If a car is to be efficiently streamlined it seems essential that it should also be stabilised if it is to be safe at high speeds in the hands of any but the most experienced drivers.

The results of this very simplified calculation have been borne out by the tests made with models by Hüber in connection with his researches into the problem of directional stability. Fig. 12 has been constructed to illustrate some of the results which he obtained. The models were run on an endless belt type of moving track, and the lateral component of the wind was simulated by a measured force applied at the centre of pressure, which had been determined from wind tunnel tests. This figure records tests representing a car

Table II

Time t secs.	Distance s feet	Deviation d feet	Yaw ψ deg	Recovery $\frac{1}{2}$s Sinψ feet	Net deviation d—R feet
0	—	—	—	—	0
.2	29	0.44	0.1	0.032	0.408
.6	88.1	1.32	0.3	0.292	1.028
1.	146.7	2.2	0.6	0.808	1.392
1.5	220	3.3	0.9	1.83	1.47
2.	293.4	4.4	1.3	3.23	1.18
3.	440	6.6	1.9	7.28	—.68

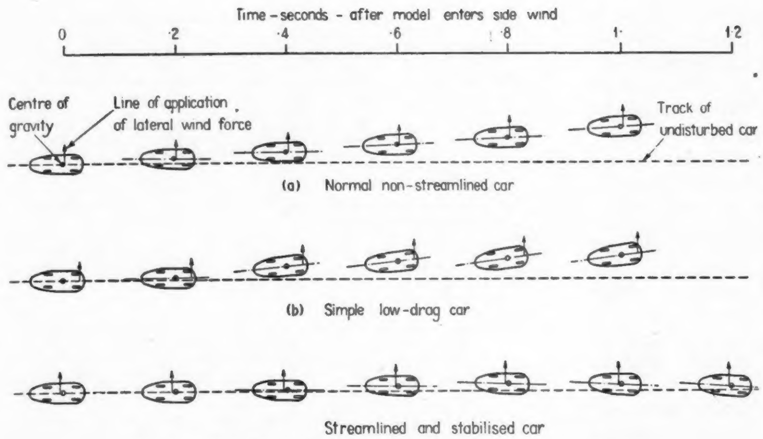


Fig. 12. The effect of side wind gusts on various types of car.
Based on results of tests made at the Stuttgart Research Institute with models towed at 100 km. per hour through an area of lateral wind of 14 metres per second.

speed of 100 kilometres per hour with a side gust of 14 metres per second velocity, suddenly applied. It appears that the models used both had the centre of gravity and the neutral steer line located at the middle of the wheelbase.

Fig. 12(a) records the reaction of a normal type of saloon car. The centre of pressure is close in front of the neutral steer line and though the car has turned a little, its reaction is primarily one of lateral drift away from its course due to equal slip of the front and rear tyres. This of course was the condition assumed for the approximate calculation.

Fig. 12(b) shows the result of a test on a production type of "streamlined" saloon car. Whilst the lateral force acting in this case may be smaller than that on the ordinary car, the total reaction is much more violent, for this car is turning rapidly away from the wind on a curving track. This characteristic is due to the location of the centre of pressure right at the front of the car. The disturbance of the model car from its track is rather less than was predicted by the simplified calculation, but this may be explained by the smaller side thrust to which the simply streamlined model was subjected as compared with the unstreamlined model.

Fig. 12(c) gives the result of a test from a model car fitted with a properly streamlined and stabilized body. This body had fins on the top corners at the rear. The centre of pressure was thus moved aft of the neutral steer line, probably by about 2 per cent of the wheelbase length. This model shows no serious deviation from its original course during the period of the test, since it has finally turned slightly into wind to accommodate the lateral slip of its tyres and it is edging right back on to its original course. Such a car is said to be "course stable" though, in fact, it will probably creep over to windward if left unchecked.

These three model tests, though based on a completely different theoretical analysis of the existing conditions, substantiate the results obtained from the preceding, simplified calculation. The analysis made by Hüber was based on the consideration of all the forces acting upon the car, resolved individually as yawing moments about the centre of gravity. This method tends to complexity and does not readily allow for consideration of any self-steering properties which the suspension system may have, but it was perfectly satisfactory for the unsprung models to which it was applied. Hüber reached the general conclusions which have been attributed to Olley as regards ground stability, before beginning his investigation into the effect of lateral wind forces.

Hüber carried out several further tests under different conditions. The centre of gravity of the models was moved forward in several steps, without change of external shape. It was found that with 60 per cent of the car weight on the front axle, leaving the centre of pressure some 10 per cent of wheelbase aft of the neutral steer line, this model made a gradual turn into the wind, in about $1\frac{1}{4}$ sec. and showed extremely little downwind drift.

With the centre of gravity moved still further forward to put 70 per cent of the loading on the front axle thus leaving the centre of pressure about 20 per cent of the wheelbase length aft of the neutral

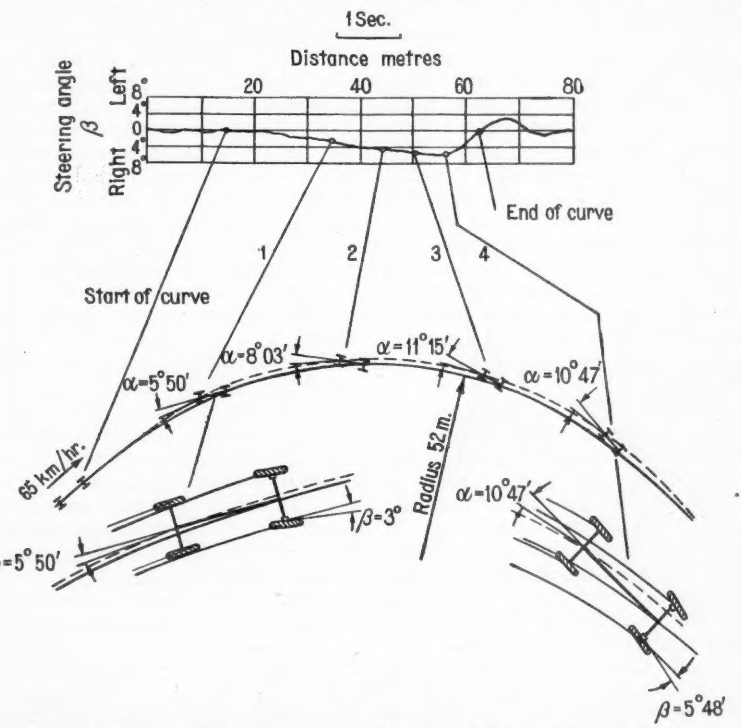


Fig. 13. Car attitudes around a curve of 52 metres radius at 65 km. per hour.
Tar macadam surface centrifugal force 0.65 g.

steer line, this model turned violently towards the side wind.

Tests were also made at 6, 14 and 20 metres per second lateral wind velocity to investigate the effect of variations of gust strength. These showed the time required for the aerodynamically stabilised car to settle in its new attitude after the application of the side force. This was practically independent of the magnitude of the side force, at a given road speed, but the maximum lateral drift off course increased rapidly with the strength of the side wind.

The conclusions drawn by Hüber from all his work are, that to be fully course stable a car must have:

(a) "an inherent understeering characteristic on its wheels."

(b) "the correct synchronisation of the yawing couples produced by aerodynamic and road forces."

This conclusion might otherwise be expressed that the centre of gravity of the car must be located in front of the neutral steer line, to produce a positive road stability margin. Also the body should be so shaped that the aerodynamic centre of pressure lies aft of the neutral steer line by the amount of the positive aerodynamic stability margin. Hüber's experiments indicated that the aerodynamic stability margin should be between 2 and 10 per cent of wheelbase length.

The ideal car may thus be envisaged as one which is completely non-responsive to side wind forces by steering itself to balance the tyre slip against aerodynamic side thrust. This is only an ideal though it might be achieved under a limited range of conditions. The difficulty, in the general case, lies in the fact that an extremely violent side gust might correspond at the most to 10 deg tyre slip angle whereas the aerodynamic force might reach its maximum value at 20 deg or even 30 deg angle of attack of the car on the relative wind.

Further, the side force due to a given transverse wind velocity increases with the road speed of the car. Whilst the resultant angle of attack of the car on the wind decreases in inverse proportion as the road speed rises with corresponding reduction in the side force coefficient, the resultant force varies as the product of the coefficient and the square of the speed. The aim of the designer should thus be to so proportion the car that it will never give rapid response to wind gusts from the side, whatever its speed. Its wind response should be so slow as to permit final, accurate, directional adjustment by the driver at his leisure.

Cornering

A car in most countries will spend a large proportion of its life travelling on curved courses, when it is by nature more difficult to control than on the straight. Since it has frequently been suggested that aerodynamic stabilising fins are detrimental to a car's cornering abilities, this condition also has been investigated. It has been found that correct course stabilisation will, in fact, be beneficial to the cornering behaviour of a car.

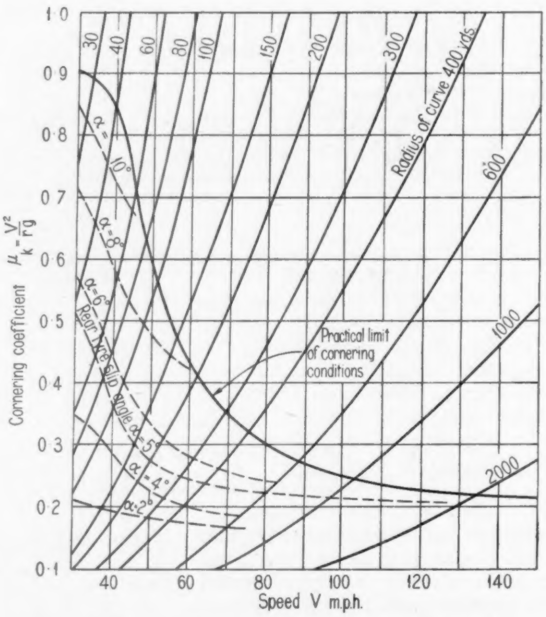


Fig. 14. Tests of cornering conditions with front wheel drive car, showing relationship between speed, radius of curve and slip angle of rear tyres.

Before making an analysis of this condition it is well to appreciate what actually takes place when a car is put fast round a bend. In this connection the series of experiments made by Deitz and Harling are very helpful. The cars were equipped to record synchronously the steering angle, β, of the front wheels, the slip angle, α, of the rear wheels, which was also the attitude angle of the car, unless the axle was displaced, whilst the car was being driven round a curve. With the aid of a time base these observations were plotted out to show the attitude of the car right through the curve, see Fig. 13.

This illustrates rather arduous cornering, and it will be noticed that the car is moving at a very oblique attitude along its track. Over 10 deg of tyre slip angle at the rear is required to provide the requisite lateral guiding force. The front tyre slip angle is even greater since some 6 deg of steering angle was also employed. Fig. 14 has been constructed to illustrate the conclusions reached from a large number of such tests. It shows the relationship between attitude angle and speed for a complete range of corner radii, and also what was considered to be the maximum practicable speed for each radius. From this figure it would appear that an attitude angle of 5 deg is a fairly normal condition for cornering, whilst at low speeds 10 deg may be expected, and even 15 deg is possible.

Fig. 15 (a) shows the attitude taken up by, and the resolution of forces acting upon a car following a curved path at low speed. In this case there is little centrifugal force, consequently little tyre slip and the car points in the direction of travel, so that air resistance can exert no influence over the directability. For comparison Fig. 15 (b) shows the case for arduous cornering conditions, with a very large attitude angle. This case is that of a simply streamlined car with its centre of pressure far forward, so that the air resistance now exerts a de-stabilising force, tending to push the car into a turn of closer radius by reducing the lateral guiding force required, hence the slip angle, of the front wheels.

This condition may be contrasted with that shown in Fig. 15 (c) which shows a similar case except that the car has now been aerodynamically stabilised, and the aerodynamic force now tends to reduce slightly the lateral guiding force demanded from the rear wheels. By thus tending to increase the radius of the car's course the directional stability of, the car is improved.

It is improbable, except perhaps under racing conditions, that the attitude angle of the car will be great enough at high speeds to

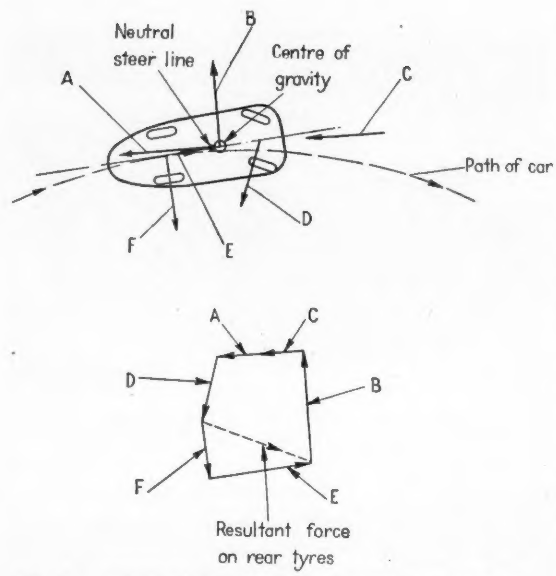


Fig. 15a. Analysis of forces acting upon a rear wheel drive car following a curved path at moderate speed.

produce big lateral aerodynamic forces in still air. Stabilising fins might not, therefore, be expected to produce any significant effect. With the aerodynamically unstable car however, there is a real danger in very fast bends, when perhaps due to surface irregularities, a condition of very large attitude angle may be reached suddenly, and the car then becomes completely out of control.

The behaviour of a car while following a continuously curved path is not a full assessment of its cornering capabilities, for conditions of entry and departure from the turn are also of importance. However, stability in following a curved path is one of the preliminary requirements for safe and fast cornering. Perhaps it is in these transient conditions of entry into and departure from the curve that striking a balance between course stability and cornering capabilities will present the greatest difficulty.

As has been remarked by Olley (1947-8), there is at present a tendency to increase the road stability margin on American cars to minimise yaw produced by aerodynamic forces. This condition is suitable for the straight roads of the U.S.A. but conditions in England, and, perhaps, indeed in most other countries, call for considerably more changes of direction, as where quick changes of direction are needed to miss the largest holes in the track. Olley (1947-8) described another feature that accompanies a high road stability margin; this is the tendency for the car to turn itself against the steering, but lagging slightly behind. This manifests itself as a tendency to continue a swerve after the steering had been centralised.

The trouble is rapidly eliminated by reduction of the road stability margin, the desirable value of which, to produce course stability, will be considerably less in the case of an aerodynamically stabilised car. From this argument it would appear that aerodynamic directional stabilisation will lead to improved general handling in bends. A feature of cars that are inherently stable by virtue of considerable excess of loading on the front wheels, is a tendency to lag in response to the steering wheel owing to the big inertia of the weight in front. In addition it seems that there is still considerable scope for design of a purely mechanical nature, to provide a steering mechanism that will enable the driver to make sudden and considerable changes of direction without extraordinary dexterity in manipulation of the steering wheel.

Good handling through bends seems to call for a small moment of inertia in yaw, relative to the wheelbase length, so that the car may respond readily to the steering. This is contrary to the present practice in suspension design, which calls for a large moment of inertia in pitch, closely allied to the value for yaw, so that the car is not disturbed by bumps acting at alternate ends. Conditions of entry into and departure from a turn bring out some of the most important characteristics of a car, but an adequate analysis of these conditions lies rather beyond the scope of the present notes. The work of Stonex is very interesting in this connection, for he has developed considerable experimental equipment for measuring the behaviour of the car under transient conditions. In this connection, experimental data from some of the more celebrated vintage cars would be interesting. It is principally for their greater ease of effecting rapid changes of direction that they were sometimes reckoned superior to all modern cars.

Location of Drive

Much discussion has been devoted by various authorities to the rival merits of front or rear wheel drive, the various conclusions reached suggesting that in fact each system would be preferable for a particular and differing set of conditions. Perhaps mechanical convenience, or price economy, may prove to be the

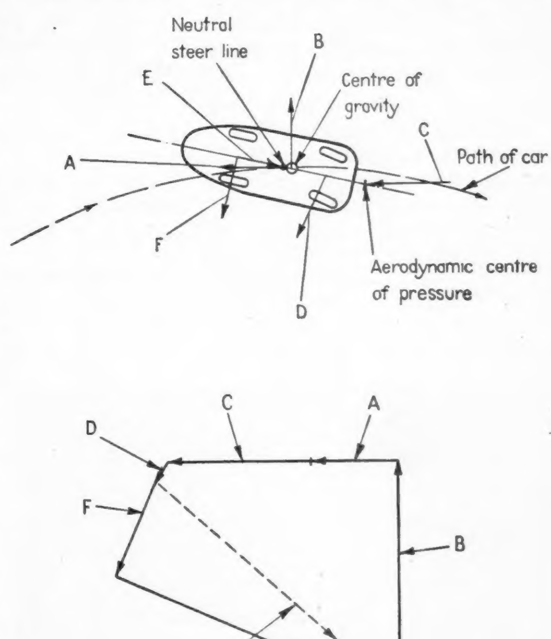


Fig. 15b. Analysis of forces acting upon an aerodynamically unstable rear wheel drive car following a curved path at high speed.

deciding factors in the choice of drive arrangement. The one certain fact is that the handling properties of the two types are quite different, and must always remain so.

Fig. 16 which is taken from the analysis made by Frére explains one aspect of this difference, the response of both types to power changes while in a curve. The horizontal force exerted by a tyre is limited to a value of $\mu \times$ load (μ being the coefficient of friction) which may act in any direction, being composed of the vector sums of propulsive thrust and the lateral guidance.

This figure shows how the available lateral guiding force for each end of the car varies with the propulsive thrust, for both types of drive. The front wheel drive car will always slide outwards at the front. Owing to the varying effect of weight transference the rear wheel drive car will tend to slide first at the front at low or moderate powers. At higher powers, above 120 kg. thrust, it will skid first at the rear, owing to the available wheel adhesion being mainly absorbed in propulsion. This change of characteristic of the rear wheel drive car would suggest that front wheel drive is safer. The front wheel drive car is however only safe so long as the throttle is kept open.

Fig. 16 also shows that the rear wheel drive car is always capable of transmitting a greater propulsive thrust than the equivalent front wheel drive car. It is primarily for this reason that front wheel drive is considered impracticable for sports models with a high power weight ratio and for racing cars. Such vehicles are invariably very low built, and further they generally have a considerable preponderance of loading on the rear wheels, in order to ensure maximum adhesion. It is apparent that care is necessary in their design if they are also to be directionally stable.

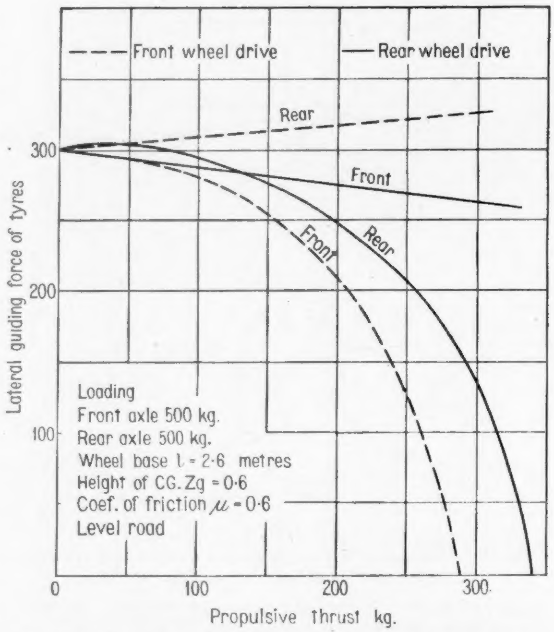


Fig. 16. Change of available lateral guiding force of tyres with driving power.

There can be no fundamental difference between the two systems as regards requirements for straight course stability. Both must have the neutral steer line located aft of the centre of gravity under all conditions of loading. Further, the aerodynamic centre of pressure should be located in a suitable position aft of the neutral steer line. The only difference between the two types is that due to variation of tyre slip angles with propulsive thrust, which would move the neutral steer line as the power is changed. This change of slip angle is in fact very small, perhaps about 5 per cent change of slip angle at the most, though it would seem from analysis of the tests by Deitz and Harling and comparison of their results with Bull's work that it varies with different makes of tyre, since the two sets of tests indicate a difference direction for the change.

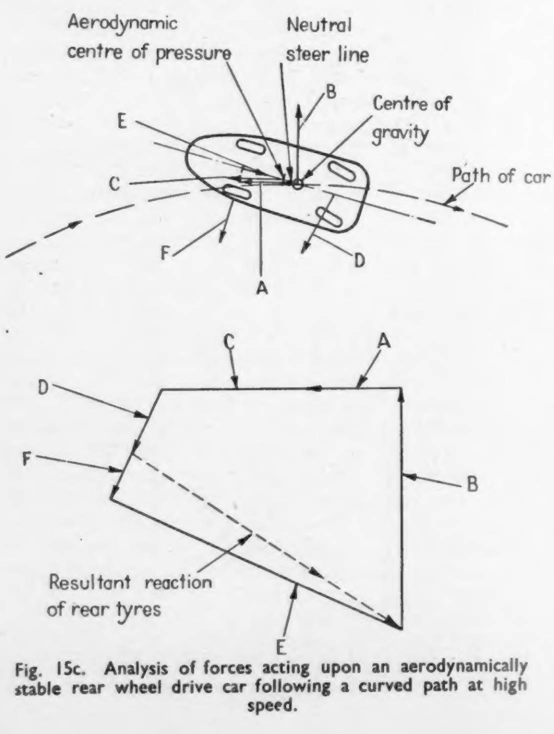


Fig. 15c. Analysis of forces acting upon an aerodynamically stable rear wheel drive car following a curved path at high speed.

In this case allowance should be made in the design of either system of drive for small changes of stability margin due to power changes. The effect of braking should not be to disturb the stability, as presumably the brakes will work on all four wheels. During travel on a straight course the propulsive thrust will be along the axis of the car, so that it will not produce any yawing couple in either system. In the extreme case, when the lateral disturbing force reaches the limit of adhesion of the tyres, the driving wheels will probably skid first, so that the front-wheel drive car will remain stable whilst the rear-wheel drive model will suddenly become unstable. Similar conditions are encountered at the limiting propulsive force, though this state will generally be reached later by the rear-wheel drive car than by the front-wheel drive one, as has been explained by Röhr.

Under fast cornering conditions a far forward centre of aerodynamic pressure must be de-stabilising for both systems. Its mechanism of reducing the requisite lateral guiding force of the front wheels will however raise the limiting cornering speed for the front wheel drive car, since in this case the front tyres carry the additional force of the driving thrust, and thus reach the limit of adhesion earlier than the rear ones (see Fig. 16).

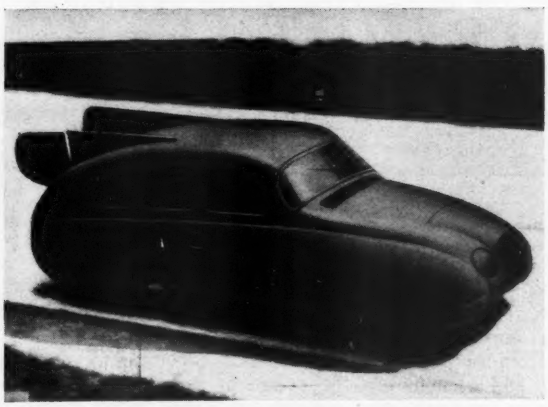


Fig. 17. Streamlined $3\frac{1}{2}$-litre B.M.W. saloon built by the Stuttgart Research Institute, with stabilising fins added.

Practical Application

Many early speed record cars were fitted with tail fins, but they can hardly be placed in the category of the aerodynamically stabilised, for it seems improbable that their designers had available the data necessary to design for real course stability. The amount of finning also seemed to vary from year to year. The first scientific application of this technique was undoubtedly made in Germany. Fig. 17 shows the $3\frac{1}{2}$-litre B.M.W. saloon which was used by the Stuttgart research institute for experiments, its short streamlined body having the low resistance coefficient of $C_R = 0{\cdot}26$. The stabilising fins were fitted following the investigations made by Hüber. The vertical slot is curious. Most illustrations show this car before the fins were fitted.

The car built by Dr. Porsche for Mercedes Benz (fig. 18) to attack the world land speed record is an example of very advanced aerodynamic design. It is not only directionally stabilised, but also shaped to give no lift, because aerodynamic lift and pitching forces become very important at such speeds.

To illustrate how the design procedure might be carried through, reference can be made to the machine shown in outline, Fig. 19. With the usual front location of the engine, a movement of the centre of gravity of over 10 per cent wheelbase length was found, and consequently it was decided to locate the engine at the rear. It can be seen that the centre of gravity has now been restrained between quite narrow limits. The centre of gravity is however aft of the centre of the wheelbase, and thus it is necessary to provide some suspension steering characteristic to obtain stability. The slope of the neutral steer line indicates that this is obtained by a roll steer characteristic.

A few comparative calculations had shown that for a car of the light weight under consideration, air resistance becomes of considerable importance even at present day cruising speeds, thus a good streamlined form was required. This was aided by the rear engine location For the highly streamlined form which resulted, a centre of aerodynamic pressure well in front of the nose was predicted from consideration of wind tunnel tests of other bodies. This fact in conjunction with the light weight and rear engine location made stabilisation essential, therefore a considerable amount of finning of some form must be applied at the tail.

This is shown dotted, and its effect will be to move the centre of pressure to a stable location aft of the neutral steer line. In fact the fins were formed integral with the body by exaggeration of the four corners near the tail, which produced an unorthodox, but quite pleasing shape. This arrangement also tended to move aft the centre of pressure for lift forces. In view of the uncertainty of the methods of estimation available, it remains desirable to test the body in a wind tunnel, to ensure that the centre of pressure is actually located within the narrow limits required to produce the best directional characteristics.

Directional Oscillations

A fully developed and continuous yawing oscillation of the complete car while running with steering fixed, rarely if ever occurs. Violent yawing oscillations may be produced by the driver in the struggle to maintain direction at speed in a directionally unstable car. In cars with beam front axles, oscillations of the front wheels often reacted upon the car as a whole. With the advent of independent front suspension the many interesting oscillations produced by gyroscopic reactions of steerable wheels connected by a beam axle have disappeared. In fact, with modern design little oscillation is now ever experienced. This subject remains one of considerable mathematical interest, but is not relevant to this work.

The yawing displacement of the complete car on either side of its mean course during an oscillation may be taken as

$$\Psi = \Psi \text{ Sin } \omega t$$

and the rate of yaw

$$\dot{\Psi} = \omega \Psi \cos \omega t$$

and the angular acceleration in yaw

$$\ddot{\Psi} = \omega^2 \Psi \text{ Sin } \omega t$$

Now $\dot{\Psi}$ is also the angular velocity of the car round a curved track, so that if the velocity is 'V' the car is subject to a centrifugal acceleration

$$(\Psi)^2 r = v^2/r$$

and since $\dot{\Psi} = v/r$

the lateral acceleration becomes

$$(\dot{\Psi})^2 r = \dot{\Psi} v$$

neglecting the effects of the attitude angle due to tyre flexibility. This lateral acceleration will in turn produce a roll of the car

$$\Phi = \Psi \sin \omega(t + a)$$

and the rate of roll

$$\dot{\Phi} = \omega \Phi \cos \omega(t + a)$$

which is a measure of the work put into the suspension dampers, and which must be supplied to sustain the oscillation. However if, as is becoming general, the car has some roll steer effect, in a stable sense, whilst the natural frequency in roll is higher than that of the exciting oscillation (ω/π per second) the roll

Fig. 18. Mercedes $44\frac{1}{2}$-litre world land speed record contender.

will be in phase with the exciting force and the car will always tend to steer itself on to a straight course. On the other hand, if the natural frequency of roll is lower than the yawing excitation this 'roll understeer effect' will assist the yaw, as yaw and roll become out of phase.

A yawing oscillation would thus appear possible at a frequency above that of roll (80–90 cycles per minute) for a car with considerable roll understeer.

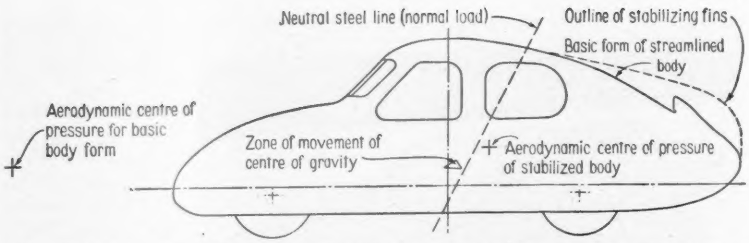


Fig. 19. Disposition of the factors affecting directional stability of a light streamlined rear-engined car.

Conclusions

The present position of motor car design technique may be said to be one of transition from the rather exotic period of trial and error, or intuitions, to a more stable period of confident design with the use of established data. Future developments will probably cease to be startling, or even noticeable at all, but the serviceability of the vehicle will be increased. Although further detailed research is necessary to clear some points, the general procedure for design to obtain directional stability is available.

1. In order to be directionally stable upon its wheels a vehicle must have its neutral steer line located aft of its centre of gravity for every condition of loading. This margin of stability should be between 2 per cent and 5 per cent of the wheelbase length. Such a car is said to understeer.

2. Any trend towards small, light cars magnifies the importance of aerodynamic forces from the point of view of performance and even more so from considerations of stability, because of the inevitable decrease of weight per unit of projected area.

3. The centre of pressure of simply streamlined bodies tends to move forward as the drag is reduced, so that streamlining will have a detrimental effect upon the stability of the car unless precautions are taken to restore the centre of pressure to a rearward position.

4. The centre of pressure should be located between 2 per cent and 10 per cent of the wheelbase length aft of the neutral steer line. This will cause the car to turn itself very slightly towards a side wind in order to counteract the lateral slip of the tyres which corresponds to the side thrust they are resisting. In combination with a positive stability margin upon its wheels, such a car is 'course stable.'

5. Further experimental data on the centre of aerodynamic pressure of motor car shaped bodies should be of great value, since the prediction of such points is not reliable. At present it would be necessary to make tests with models of every body for which it is required to fix the centre of pressure at a particular location.

6. Under high speed conditions in a curve the car may assume attitudes at which aerodynamic forces affect the stability, when an aerodynamically unstable car can get out of control. A stabilised, streamlined body is thus advantageous under conditions of fast cornering.

7. The gaining of road stability by means of a high degree of suspension roll-steer effect may result in a car that might develop a high frequency yawing oscillation, besides having slightly impaired handling characteristics.

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FINE BORING

A SPECIALLY adapted Heald No. 45 Bore-Matic, supplied by Alfred Herbert Ltd., Coventry, has been installed in the Wolseley works of Morris Motors Ltd. for boring the mainshaft and layshaft bearings in the Nuffield tractor gearbox. After loading is effected, the complete boring sequence is automatic. In addition the machine movements are fully interlocked so that the machine cannot operate unless the work is in the correct position, nor can anything happen out of sequence.

As the locating face on the work has no opening in it, the gearbox has to be loaded with the locating face upwards. Angle iron uprights are used to guide the work into the fixture. When the gearbox is released from the hoist, spring-loaded conical-head dowels seat in locating holes and close switches which allow the table to travel to the left with the boring bars stationary. As the boring position is reached, a hydraulic intermediate stop on the underside of the machine table is operated and no further movement can take place until the work is clamped.

Clamping is effected in two stages. First, two over-arms are lowered and clamped to the two uprights. Then the work is raised against the locating blocks with the two manually-operated dowels already in the locating holes. This closes two switches in the over-arms and releases the hydraulic intermediate stop, which in turn starts the rotation of the boring bars and the table travel at boring feed.

As soon as the machining is completed, the boring bars cease rotating and a plunger drops into a groove in one of the drivers. The operator then allows the work to drop. This closes the switches on the rough locating dowels, and the table automatically reverses and returns to the loading position. At this stage the over-arms are released and raised and the fixture is ready for re-loading. Operation of the over-arms and the clamping of the work are effected through air cylinders controlled by two air valves. The floor-to-floor time is 10 minutes.

AUTOMATIC MACHINES

Important Developments by A. C. Wickman Ltd.

TO meet the demand for machines that will accommodate larger diameter stock than the established range of five-spindle machines, A. C. Wickman Ltd., Coventry, have introduced two new multi-spindle automatics, one with four spindles for bar up to $3\frac{1}{2}$in. diameter, and one with six spindles for bar up to $2\frac{5}{8}$in. diameter. These machines are designed on basically similar lines to the existing five-spindle machines, but they incorporate refinements and improvements to make them suitable for the heavy work for which they are intended.

In addition to accommodating larger diameter stock, these new machines have also been designed to allow full advantage to be taken of the metal removing capacity of modern carbide tools. Great rigidity, freedom from vibration and ample power are therefore essential. The method of frame construction and the generous proportions of all bearings ensures rigidity and freedom from vibration under even the heaviest cuts. Ample power for machining the toughest materials at a high rate of metal removal is supplied by a 40 h.p. motor.

Spindle and Feed Drives

The drive is transmitted from the motor through heavy vee belts to a constant speed shaft. From this shaft, a second shaft is driven by a range of gears to give high-speed and low-speed ranges. Individual speeds are obtained through pick-off gears. The coolant and oil pumps, and the high speed clutch which is engaged during all non-productive movements of the machines, are also driven from the constant speed shaft.

A central shaft passes through the spindle drum to drive the spindles. From this shaft are also driven the feed drive which controls the production cycle time and the various standard and special end-working attachments. Feed drive is effected initially through a primary reduction, then through two pairs of pick-off gears for variation of the cycle time to a safety clutch and a roller-type overrun clutch integral with the slow side of the fast-and-slow clutch for controlling the non-productive and productive portions of the operation cycle. It is then transmitted through a second safety clutch and a power feed clutch. The two safety clutches are rated to protect the mechanism of the machine during feed and fast - motion operation respectively.

Spindle Drum

High tensile steel is used for the spindles which are carried on precision pre-loaded anti-friction bearings and are fitted with hardened collet seatings. Operation of the drawback collet on each spindle is effected by means of normal fingers and springs which compensate for variations in bar size. The spindle drum is made from high hardness seasoned cast iron to very close limits of accuracy. For example, the locator pieces by means of which the drum is positioned at every index are ground to a maximum tolerance of 0.0002in. for spacing. Similarly, the bores for the spindle bearings are equally spaced in relation to each other and to the centre bore and the outside diameter within plus or minus 0.0002in. The hardened and ground collet seatings run true within 0.0005in.

A modified Maltese-cross mechanism, working through gears, is used for indexing the drum. This is so arranged that at each cycle the drum is indexed slightly past its correct position and then smoothly and positively drawn back on to the locators by a powerful toggle clamp. This arrangement virtually eliminates wear in the locating mechanism and ensures indexing accuracy throughout the life of the machine. A clutch is provided for disengaging the drum indexing, bar feed, collet operation, and drum locking mechanism to allow repeated trial cuts to be made at individual stations when the machine is being set up. A stop ring is fitted at the front of the spindle drum with individual stop screws for each spindle in all positions. This allows small sizing errors to be cancelled out.

The bar feeding slide is controlled by a cam directly below it. Adjustment is provided for varying the stroke. Two cams cover the full range. Bar feed is effected by means of a powerful adjustable spring. Collet operation is direct from the cam to a slide with alternative hand operation. The bar stop is arranged for operation in either of two directions, according to which is the more suitable for the tooling arrangement in use.

Auto-setting

As with the earlier Wickman multi-spindle automatics, these machines incorporate a patent quadrant linkage mechanism which provides an infinite variation of feed strokes without any cam changing. With this mechanism, simple sliding adjustments on graduated scales effect alterations to the longitudinal and cross slide working strokes and bar feed from zero to the maximum while retaining unaltered the full fast approach stroke. This mechanism eliminates the need for expensive interchangeable cams for different classes of work and also considerably reduces change-over and setting times. Because of this, these multi-spindle machines can be used economically on relatively small batches.

The mechanism controlling the movement of the main tool slide, and the two auxiliary slides when fitted, is conveniently mounted above the drive housing. A transversely mounted camshaft carries fixed cams and the quadrant linkage mechanism. Rapid and accurate setting of feed strokes for end-working tools is effected by sliding the setting blocks along the graduated scales fitted to the quadrants. Without any further adjustment the tool strokes are set precisely.

Actuation of the centre block and auxiliary slides is effected by pusher racks to which the motion of the quadrants is transmitted by means of racks and pinions. The quadrants receive their motion from the standard cams. Other cams on the same shaft control the fast approach and return motion. Similar mechanisms control the movement of the cross slides. Adjustments to cross slide feed strokes are effected by sliding blocks on readily accessible quadrants.

The main camshaft extends from the worm wheel in the drive housing, through the drum housing to the stock carriage end of the machine. It carries the cross slide feed and approach stroke cams, bar feed and collet operating cams, spindle drum locking cams, the arm of the Maltese-cross mechanism and the indexing clutch. It will also accommodate cams for auxiliary attachments when they are required.

A cam drum is fitted in the attachment drive housing to carry cams for special end-working attachments when these are required. There is also a cam disc in the drum housing to which cams can be fitted for varying independently the

The new Wickman six-spindle automatic.

movements of the cross slides or cross slide attachments. The upper camshaft, which is transversely mounted across the top of the drive housing, carries disc cams for the operation of the end-working slides and attachments. It also carries the dogs for controlling the fast-and-slow clutch and a timing dial at the front for indicating the timing of all machine movements.

Tool Slides

Two lower and two upper cross slides are provided on both the four-spindle and six-spindle machines. On six-spindle machines an additional cross slide is used for parting off at the front, and a further auxiliary cross slide can be fitted at station 3 as optional extra equipment. All cross slides have micrometer adjustment. With the exception of the part-off slide, all slides are fitted with master stops to work against the individual stop screws in the spindle drum stop ring for size control. Each cross slide has an infinitely variable feed stroke and a virtually constant approach stroke. The advance stroke is effected by a toggle which remains locked during the feed stroke.

The central main tool slide is hexagonal on the six-spindle and square on the four-spindle machine. On each machine, it is exceptionally long and provides ample capacity for mounting tools and attachments. The main tool slide for end-working is fitted with bushes and a scraper ring. It slides on a large diameter nitrided central stem. All torque is taken by the guide arm. Two auxiliary slides for mounting on the beam in stations 4 and 5 on the six-spindle machine, and in stations 3 and 4 on the four-spindle machine, are available as optional extra equipment.

The mechanism for operating the main tool slide, and the auxiliary slides when they are fitted, is similar in principle to that on existing Wickman multi-spindle automatics, but it is of much more robust construction. It provides a constant approach stroke and an infinitely variable feed stroke. The mechanism which imparts the approach stroke is securely locked during the feed stroke. To suit the requirements of the tool lay-out, the timing of the end-working slides in relation to the cross working slides can be adjusted within certain limits.

Pressure lubrication is employed. It is effected by means of a pump which circulates oil from the sump to the gear box and attachment drives, and supplies oil from a tank to the spindle bearings. Provision is also made for a copious supply of cutting fluid. For this, a large gear pump feeds coolant to distributor headers at each side of the machine and to cocks adjacent to the lower cross slides.

As these machines are capable of very heavy stock removal, the machine design allows ample space for clearing swarf. In addition, a standard swarf conveyor has been designed for use with these machines. A chute below the tooling directs the swarf into the trough of a screw-type conveyor for ejection into a receptacle or conveyor outside the machine. The screw conveyor is driven by an independent motor and reduction unit mounted on the outer end of the conveyor. The complete unit is easily removed for cleaning and servicing. This unit is optional additional equipment.

The principal particulars for these machines are :—

	6-spindle	4-spindle
Max. bar diameter	$2\frac{5}{8}$in.	$3\frac{1}{2}$in.
Max. bar feed ..	10in.	10in.
Feed stroke on main tool block ..	0—5in.	0—5in.
Feed stroke on 4th and 5th slides ..	0—$5\frac{1}{2}$in.	—
Feed stroke on 3rd slide	—	0—$5\frac{1}{2}$in.
Feed stroke on 4th slide	—	0—$3\frac{3}{4}$in.
Standard idle stroke to end-working slides	$3\frac{1}{2}$in.	$3\frac{1}{2}$in.
Special idle stroke to end-working slides	5in.	5in.
Max. length turned with standard idle stroke cam ..	9in.	9in.
Lower cross slides idle stroke ..	$1\frac{3}{4}$in. min.	$1\frac{3}{4}$in. min.
Lower cross slides feed stroke ..	0—$1\frac{3}{4}$in.	0—$1\frac{3}{4}$in.
Upper cross slides idle stroke ..	$1\frac{1}{4}$in.	$1\frac{1}{4}$in.
Upper cross slides feed strokes ..	0—$2\frac{1}{2}$in.	0—$2\frac{1}{2}$in.
Auxiliary cross slides idle stroke	$1\frac{1}{2}$in.	—
Auxiliary cross slides feed stroke	$\frac{1}{4}$in.—$1\frac{3}{4}$in.	—
Spindle speed range, 24 steps .	80—1000	60—800
Range of cycle times, seconds .	7.1—922	7.1—922
Idle time — tool return, index, tool approach ..	3 secs.	3 secs.

Attachments

A series of attachments, specially designed for use with these machines, adds greatly to the classes of work that can be handled. They make provision for threading, high speed drilling, independent reaming, auxiliary motions for special tooling, deep hole drilling and thread rolling.

On the six-spindle machine, and using the appropriate attachments, threading can be carried out at stations 3, 4, 5 and 6 in any combination, or from all four stations. Two attachments cover the range. They are constructed for application to stations 3 and 6, and 4 and 5 respectively. Both can be used for dieheads, collapsing taps, solid dies or taps in combination with the appropriate drive.

The drives for these attachments are taken from interchangeable jackshafts, one driving attachments in stations 3 and/or 4 and the other attachments at stations 5 and/or 6. These jackshafts are chain driven from the central drive shaft at the same speed as the spindles. Use of the threading attachments at stations 4 and/or 5 necessitates the employment of the auxiliary independent slide and its appropriate operating mechanism. Threading attachments for stations 3 and 6 are mounted on slides bolted to the centre block. They are actuated by an auxiliary longitudinal motion which is also used for independent reaming at the same station. If threading is carried out at station 6, the attachment is accelerated before parting-off.

On the four-spindle machine, threading can be carried out at stations 3 and 4 together or individually. The attachment is interchangeable between the stations. Use of the attachment in either position necessitates the employment of the auxiliary independent slide and its appropriate operating mechanism. This attachment is universal in application.

High speed drilling attachments are available for both machines. They are designed to accept Morse taper shank drills. They can be used at any or all stations and a comprehensive range of speed ratios is available. The attachments are mounted either on the centre block or on the independent slides, if these are fitted. On the six-spindle machine the drill spindle assembly may be mounted in the standard independent reaming attachment at stations 3 or 6 to obtain an independent feed rate.

Independent reaming attachments are available for use at stations 3 and 6 on the six-spindle machine. Although they are specifically designed for reaming operations they can be used for other end-working tools of the shank type. They will also accommodate the high speed drilling assembly. The same auxiliary motion is used as is employed for the threading attachments at stations 3 and 6. It provides a range of feed strokes from the standard cams.

A deep hole drilling attachment has been developed for application to stations 4 and 5 on the six-spindle machine, and to stations 3 and 4 on the four-spindle machine. It embodies a self-relieving mechanism that allows holes up to 12 or 14 diameters deep to be drilled in much less time than is necessary with the normal cam relieving technique. For example, on a 60 seconds cycle time, 35 seconds would be required for two reliefs by cam relieving technique, whereas the Wickman relieving attachment would perform four reliefs in a total time of $2\frac{1}{2}$ seconds. Frequency and number of reliefs are controlled by a trip plate and can be varied to suit the drilling conditions.

A thread rolling attachment is available for use on any cross slide of the six-spindle machine. It consists essentially of a pair of thread rolls diametrically opposed above and below the workpiece to which they are applied radially. The radial in-feed is self-generated and instantaneously self-relieving.

"The Autocar" Motorists Diary

London : Iliffe and Sons Ltd., Dorset House, Stamford Street, S.E.1. 64 pp. of reference material, plus the usual diary pages of a week to an opening. $4\frac{1}{2} \times 3\frac{1}{8}$. Morocco leather 5s. 6d., rexine 3s. 8d., including purchase tax.

THE diary for 1951 includes special reference matter for the motorist, and pages are provided for keeping a detailed record of running expenses and of car maintenance, and for the sporting-minded motorist there is a section giving race winners and average speeds for the important races and hill-climbs since their inception, as well as a summary of world's and class records. The diary also includes a directory of the chief motoring club secretaries' addresses, and the inclusion of British and International Road Signs will be welcomed by all readers.

Solex Gauges

FOUR new publications recently issued by Solex (Gauges) Ltd., Solex Works, 223/231 Marylebone Road, London, N.W.1, will be of interest to all automobile engineers, and indeed to all engineers concerned with production to fine limits. Three of these publications are catalogues, one general, and the other dealing respectively with external and internal Solex gauging systems. They give adequate descriptions of the Solex principle and of the different types of equipment.

The fourth publication deals solely with equipment developed for gauging automobile pistons. As is well known, an automobile piston has many elements which must be correct to very close limits and which must also be in accurate relation to each other.

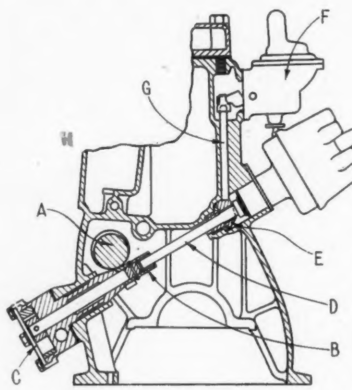
CURRENT PATENTS

A Comprehensive Review of Recent Automobile Specifications

Auxiliaries Drive

BY this driving arrangement three vital auxiliary components, oil pump, distributor and fuel pump, can be most advantageously positioned on the engine for attention or easy detachment. From the cam shaft A, a sleeve B secured to the spindle of oil pump C is driven by a spiral gear. Distributor shaft D is furnished with splines at its lower end to engage sleeve B and also with identical splines to furnish a driving connection for eccentric E. From this member fuel pump F is actuated by means of push rod G.

It will be noted that the fuel pump is mounted on the side of the engine opposite to that on which the exhaust manifold is located. This enables the fuel line from the rear-mounted tank to be conveniently run forward to the pump by the shortest route and remote from the heat of the



No. 625400

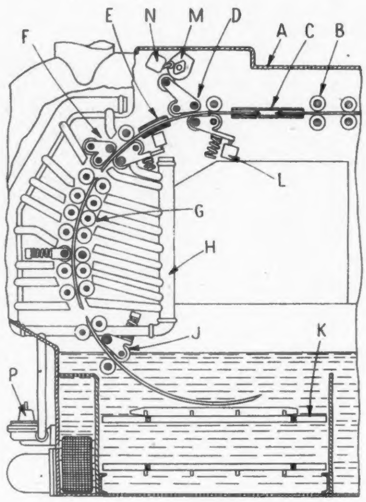
exhaust system. The risk of vapour lock is minimized, the fuel pump is brought to an accessible position and approximately three feet of fuel line is saved. *Patent No.* 625400. *Ford Motor Co., Ltd.*

Continuous Production of Leaf Springs

AS a consequence of the heavy presses required to form leaf springs and to restrain them to the prescribed curvature during heat treatment and quenching it has been difficult to establish a flexible and rapid manufacturing routine. The invention proposes apparatus by means of which stock material is progressed automatically through heating, bending, reheating, quenching and cooling operations with the minimum of attention. The main casing A has a fluid-tight lower portion containing a bath of the quenching coolant. Between the walls of the housing is an array of elements comprising stock feed rolls B, high frequency heating coil C, initial bending mechanism D, reheating coil E, final bending mechanism F, maintaining rolls G, quenching apparatus H, delivery rolls J and discharge conveyor K.

Spring leaves, cut to length and with their ends tapered and feathered, are loaded from the exterior of the housing and carried forward by the feed rollers at appropriate speed to ensure adequate heating as each passes through the first coil. At the bending mechanism it is first engaged by a gauging roller actuating a limit switch L. In association with this the bending roller is adjusted by means of cam M and a second limit switch N to maintain the appropriate degree of curvature despite variation in the thickness of the stock at the ends.

The bent stock then passes through the second heating coil adjusted to raise its temperature above the critical point of the steel and is then subjected to the final bending operation in mechanism F which, although not shown in detail, has similar gauging and control devices as provided for the initial bending mechanism. After this bending it is engaged between a series of rolls to maintain the prescribed curvature and quenched by coolant delivered by pump P through headers and jets arranged on each side of the spring. Leaving the quenching apparatus the spring is projected through the delivery rollers and falls on to the receiving flight of the discharge conveyor by which it is lifted out of the bath and delivered to the exterior of the apparatus. *Patent No.* 624818. *Ford Motor Co., Ltd.*

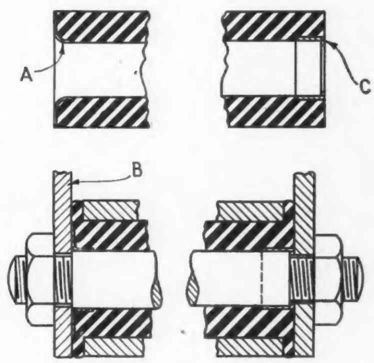


No. 624818

Flexible Bearing Bushes

IN flexible bearings of the type in which a rubber bushing is axially compressed between side plates, there is a risk when assembling of distorting the ends of the bush inwardly and nipping them between the end plates and the shoulders of the spindle. The invention aims to obviate this possibility. During the moulding of the bush, a facing A of rubber-treated textile fabric is incorporated at the internal periphery at each end and extending over the end surfaces. This facing resists distortion and supports the end of the bush when the end plate B is drawn up to the spindle.

As an alternative method an internally

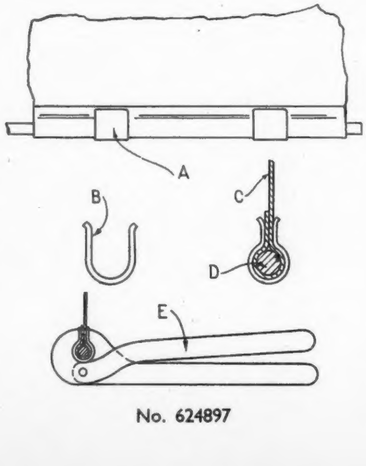


No. 621333

flanged metal ring C may be located at each end of the bush. The flanged end of this ring is flush with that of the bush and adapted to pass freely over the reduced end of the spindle and engage the shoulder. During assembly it furnishes complete support for the bushing and finally the flange is clamped between the spindle shoulder and the end plate. *Patent No.* 621333. *Dunlop Rubber Co., Ltd., and H. Wilson.*

Attaching Upholstery Fabric

INSTEAD of stitching or tacking upholstery fabric to the frame of a seat or squab, attachment is secured by means of a series of deformable metal clips A. These are of a relatively soft metal, such as mild steel, and are initially formed to U-shape with the tips inclined outwardly, as shown at B. The margin of the fabric C is wrapped over the bar or rail D of the frame and clips A are located at convenient intervals. By means of a suitably designed pair of tongs E the arms of the clip are crimped into tight contact with the double thickness of fabric adjacent to the bar. A neat and secure fastening is thus obtained more quickly than can be effected by sewing or tacking. *Patent No.* 624897. *Austin Motor Co., Ltd., and H. Challenor.*



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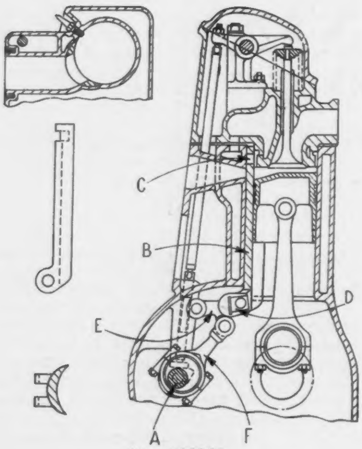


No. 620083

Engine Valve Gear

THE use of crescent-section valves sliding in recesses in the cylinder bore has been proved in practice but it has been found that a larger inlet port area than can be provided in this type of valve is necessary to obtain high mean effective pressures. The proposal, therefore, is to use a crescent slide valve, which can be efficiently cooled, for the exhaust, and an overhead poppet valve which can be as large as desired. Preferably the crescent valve is arranged in the cylinder bore on the side opposite to that receiving the major thrust.

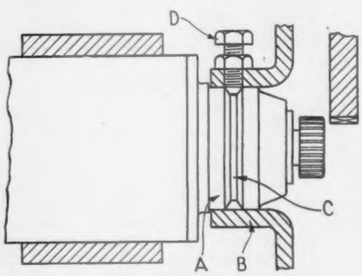
In the example shown, the inlet valve is operated by a push rod and rocker from camshaft A mounted in the crankcase. Crescent valve B is slidable in a part-cylindrical vertical groove in the cylinder bore and has near its upper end a tranverse port C. Twin lugs at the lower end of the crescent valve carry a pin on which is mounted a slipper block D guided between the horns of a lever E pivoted on the crankcase. To a short arm on lever E is pivoted the end of rod F actuated from an eccentric on the camshaft. *Patent No.* 620083. *Austin Motor Co., Ltd., and J. C. Haefeli.*

Power-assisted Braking System

IN this hydraulic system manual effort is supplemented by fluid pressure generated by a pump driven from the vehicle transmission. It is particularly suitable for six- or eight-wheeled vehicles where the displacement of the master piston to operate the brake cylinders is necessarily large. Furthermore, on such vehicles the fluid pressure generated by the pump may be utilized for other purposes, such as door opening, and the invention will prevent such extraneous use until sufficient pressure is established for brake actuation.

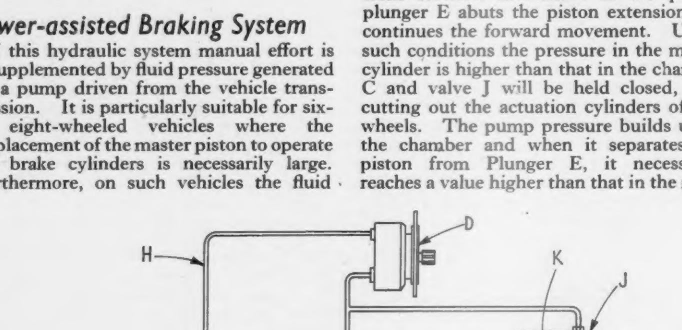
On a six-wheeler, the brakes of four wheels are connected by conduit A to a master cylinder unit B, the piston of which is exposed at its rear face to a chamber C into which fluid is delivered under pressure by the mechanically-driven pump D. In the reduced diameter rearward extension of the master cylinder is a plunger E operatively connected to pedal F. An axial boring in the plunger furnishes an outlet from chamber C, while the recessed end of the plunger co-operating with an extension of the master piston constitutes a variable restriction of this passage. The outlet is connected by conduit to reservoir G from which the pump D draws fluid through conduit H.

The pump delivery conduit is branched to a valve J, the outlet from which is connected to the actuation cylinders of the brakes of the two other road wheels. Plunger K of this valve is urged towards its seat, cutting off the inlet of fluid from the pump, by pressure from the main fluid system including the master cylinder.



No. 623171

When pedal F is depressed plunger E approaches the piston extension, thus restricting the flow out of chamber C and the pressure builds up to move the piston forwardly and apply the brakes. Should the pump be running so slowly that the delivery of fluid is insufficient to fill the increasing volume of the chamber resulting from forward movement of the piston, plunger E abuts the piston extension and continues the forward movement. Under such conditions the pressure in the master cylinder is higher than that in the chamber C and valve J will be held closed, thus cutting out the actuation cylinders of two wheels. The pump pressure builds up in the chamber and when it separates the piston from Plunger E, it necessarily reaches a value higher than that in the main fluid system. Plunger K of valve J is then lifted from its seat and pressure is applied to the additional wheel brakes. *Patent No.* 622617. *Automotive Products Co., Ltd., and L. C. Chouings.*



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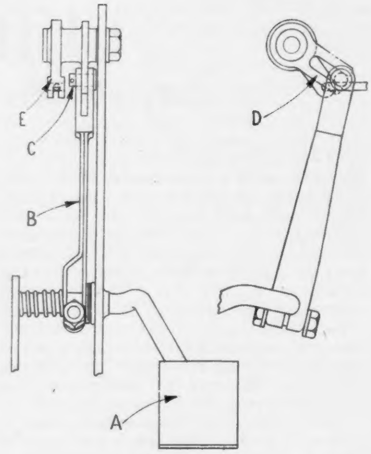

No. 624290

Locating Electrical Components

GENERATORS and starting motors are commonly mounted in a cradle support and positioned both axially and radially by means of a screw-threaded dowel. As the position of the radial hole varies for different engines, bulk production of electrical units to a common standard is not possible. To avoid this disadvantage the body of the component, in this case a starting motor, is furnished with an extended barrel portion A which projects into a cylindrical boss B on the clutch housing. A circumferential groove C, with tapered sides, is formed in the barrel portion and is engaged by a conical-ended screw D, arranged at any convenient radial position on the boss. Axial location is thus ensured and the component can be turned radially to its desired position and locked by the set screw. *Patent No.* 623171. *C.A.V., Ltd., and A. T. C. Priddle.*

Throttle Control Linkage

WITH the usual form of butterfly valve for controlling the mixture flow the angular position of the valve and the flow area afforded has a non-linear relationship. At small throttle openings engine control is somewhat less sensitive than at larger openings and the object of this invention is to mitigate this feature. On the shaft of the accelerator pedal A is adjustably secured a crank arm B, the upper end of which is forked and fitted with a pin C. Parallel to the accelerator shaft is mounted a stub shaft on which pivotes a short crank arm D, furnished with a lever E by which motion is transmitted through suitable linkage to the butterfly valve spindle.

Arm D is slotted to engage the pin carried by arm B and the two are disposed so that when the accelerator is in zero position and the butterfly valve is closed the angle between the two exceeds 90 deg. At the commencement of opening motion the angular movement of arm D will be at a minimum for a given angular movement of arm B and the ratio will increase as the opening movement is continued. It is claimed that with suitable proportions and disposition, control is more certain and engine acceleration at small throttle openings is rendered much easier. *Patent No.* 624290. *Humber Ltd., A. C. Miller and G. Berry.*